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MILITARY OPERATIONS RESEARCH SOCIETY

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SIMTECH 2007
Mini-Symposium and Workshop

Session 1
16-18 December 1997 — GRCI, McLean Virginia

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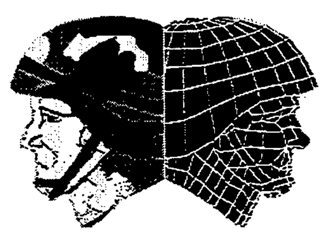
18-20 August 1998 — IDA, Alexandria Virginia

Chair
Dr Stuart Starr, FS



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Executive Summary

1. Background. Approximately a decade ago, the Military Operations Research Society (MORS) sponsored a series of three workshops under the rubric of Simulation Technology 1997 (SIMTECH 97). Those workshops focused on identifying and satisfying the simulation technology needs of the analyst in the late 1990s. Ultimately, that activity culminated with a set of findings and recommendations on four major themes: lifecycle management for Modeling and Simulation (M&S); a workstation for the analyst; dealing with "soft factors" (e.g., cognitive factors, performance modulators) in M&S; and responding to M&S's needs for data. In 1997, several of the original organizers of SIMTECH 97 believed that it was an appropriate time to re-assess the results of the prior workshops and to look ten years into the future.

2. Goals and Objectives. The overarching goal of this new series of workshops was to promote more effective dialogue between the M&S technology community and an expanded set of users of M&S: analysts, acquirers and educators and trainers.

Consistent with this goal, four subordinate objectives were identified:

- Review and assess the findings and recommendations from SIMTECH 97;
- Identify and prioritize the needs of the users of military M&S;
- Assess the probable evolution of M&S technology over the next decade; and,
- Identify opportunities to address user needs.

3. Approach. To satisfy these goals and objectives, two workshops were convened. The first workshop was conducted at GRCI, Tysons Corner, VA, on 16-18 December 1997. To symbolize the objectives of the workshop, the organizers adopted the JANUS icon; a archetypical GI looking to the past and a cyber warrior looking to the future. Consistent with those dual perspectives, Ed Brady, FS, Chair of SIMTECH 97, provided a keynote address entitled "Then & Now." That was followed by retrospective assessments by working groups organized around the four major themes that were addressed in SIMTECH 97. To set the stage for assessments of the future, the second day began with plenary presentations on M&S plans and programs in the areas of education and training (Lou Finch, DUSD (Readiness), OSD), analysis (Eric Coulter, PA&E, OSD) and acquisition (Robin Frost, DTSE&E, OSD). In addition, Paul Davis, RAND, provided perspectives on the future of M&S technology by summarizing the major findings and recommendations from a recent National Research Council study. Drawing on these presentations and the lessons learned from the retrospective assessments, the participants were reorganized into parallel clusters of M&S users and technologists. The users identified and prioritized the M&S needs of analysts, acquirers and educators and trainers. The technologists formulated a taxonomy for M&S technology and, within that context, forecast conservative and aggressive estimates for the state of M&S technology by 2007.

The second workshop was conducted at the Institute for Defense Analyses (IDA), Alexandria, VA, on 18-20 August 1998. The workshop began with a keynote

presentation by General Larry Welch (USAF, retired), President, IDA, entitled "Some DSB Task Force Perspectives on Simulation for Innovation." His remarks were followed by a series of plenary presentations on emerging revolutions in education and training (VADM Patricia Tracey, N7, USN), analysis (Vince Roske, Joint Staff), acquisition (Patricia Sanders, DTSE&E, OSD) and a cross-cutting presentation on M&S as an enabler of these revolutions (Vern Bettencourt, FS, AMSO, USA). Drawing on these inputs, hybrid working groups of M&S users and technologists refined their products from Workshop I. Subsequently, after a sequence of M&S technology presentations, these hybrid working groups identified a comprehensive set of shortfalls (subsuming policy, management and technology) and formulated recommendations to ameliorate them. These working groups completed their deliberations by performing sensitivity analyses to explore the robustness of their findings and recommendations to changes in key underlying assumptions (e.g., availability of resources).

4. Products. Four major classes of products were developed during the course of the workshops. First, a set of lessons learned from SIMTECH 97 were developed. These include the importance of documenting assumptions when dealing with a volatile world and the need to formulate technology projection envelopes (vice point predictions). In many instances, the participants validated that key SIMTECH 97 recommendations that were not fully acted on during the past decade (e.g., the need for focused programs on "soft factors" and data) remain as important priorities.

Second, several key assumptions/drivers for the next decade were identified. These include trends in missions (e.g., emerging asymmetric threats), strategy/operational concepts (e.g., continued commitment to the basic precepts underlying Joint Vision 2010), institutions (e.g., forces will be restructured and downsizing of DoD will continue), systems (e.g., heightened interest in treating the "soldier as a system"), training (e.g., increasing importance of advanced distributed learning), commercial products (e.g., increasing importance of commercial information technology products for DoD) and technology (e.g., information will be increasingly globalized and accessible).

Third, M&S technology projections were developed for the next decade. As a basis for these projections, a taxonomy was developed that can be depicted as a jig saw puzzle with four interlinking pieces: modeling methodology (i.e., the theories, processes, algorithms and information that support the conceptualization of a model); development methodology (i.e., the tools, techniques and software used in architecting, designing and implementing a model); computation and communications technology (i.e., the platform the M&S application is hosted on, how it connects to other M&S applications and how M&S application developers and users connect to one another); and data and information technology (i.e., the processes and tools needed to acquire and transform data and information). For each of these areas, technology projections were made under conservative assumptions (e.g., continuation of current investment priorities) and aggressive assumptions (e.g., substantial increase in priority with the subsequent likelihood of a breakthrough).

Fourth, for the functional areas of analysis, acquisition and education and training, top-down assessments were performed. These include an articulation of a vision for the functional area; an identification of associated needs (in policy, management and technology); a characterization of perceived shortfalls (e.g., an identification of cases where technology needs exceeded aggressive projections (assessed as "red") and cases where technology needs fell between conservative and aggressive projections (assessed as "amber")); a set of recommendations to ameliorate perceived shortfalls; and sensitivity assessments to establish the robustness of the recommendations.

5. Selected Findings. Each of the plenary speakers at the second workshop identified M&S as a key enabler to promote *revolutions* in analysis, acquisition and education and training. This hypothesis was validated by the working groups.

Several of the plenary speakers observed that many of the obstacles to these revolutions are *cultural* in nature. Among the more important cultural obstacles identified were institutional barriers (e.g., the need to go from "stovepiped" organizations to more collaborative organizations that would promote the more efficient sharing of tools, data and expertise); modeling and simulation barriers (e.g., transitioning from the inflexibility of current M&S to more flexible M&S to explore easily new operational concepts, doctrines, procedures, and the human dimension); and process barriers (e.g., transition from the use of a few, "blessed" scenarios to a full range of scenarios that span the mission space). Again, these observations were extended and validated by the working groups.

From a technology perspective, the working groups concluded that the most significant shortfalls were projected to occur in modeling methodology (i.e., adequate representation of key cognitive factors, performance modulators and computer generated forces); development methodology (i.e., system architecture/engineering; system composability, scalability; and standards for design, interoperability and reuse); and data/information understanding (i.e., tools for dealing with data acquisition, transformation, and access; tools to support collaboration). In almost all cases, these projected technology shortfalls cut across individual functional areas. It is notable that each functional working group also opined that commercial developments in communications and computing would probably *not* constrain M&S applications, with the exception of security needs.

6. Recommendations. Consistent with the selected findings, the following recommendations have been formulated.

6.1 Institutional Initiatives. To facilitate the development of a better balanced M&S Science and Technology (S&T) investment strategy, it is necessary to develop a clear, comprehensive audit trail for current M&S S&T programs and plans.

To promote needed community sharing of tools, data and expertise, organizational focal points are required for Simulation Based Acquisition (SBA) and Advanced Distributed Learning (ADL). These organizations should champion these processes, promote pilot programs, monitor commercial developments, begin to establish the community

infrastructure needed to "boot strap" the processes and assure the full scope of cross-cutting activities are undertaken (e.g., ensure that education and training needs are treated adequately in SBA).

6.2 Program Initiatives. An expanded family of flexible, readily tailorable M&S is needed to address many user needs. Although on-going monolithic model developments (e.g., JWARS, JSIMS) will probably prove to be central elements of this family, they will almost certainly not be sufficient to satisfy the needs of all users. To complement them, "boutique" models are needed that address all aspects of the expanding mission space (e.g., asymmetric conflict; new operational concepts). These include system dynamics models (to provide the ability to quickly scan and pre-filter scenario space) through virtual M&S (to capture the effects of distributed teams of people under stress). In particular, the demands of advanced warfighting experiments mandate new classes of M&S, which are sufficiently flexible to explore easily new operational concepts, and companion education and training experimentation plans to address the subjects' needs for associated training.

6.3 Research Initiatives. To redress identified M&S technology shortfalls that affect all users of M&S, undertake organized research programs in "soft factors" (e.g., cognitive factors, performance modulators, computer generated forces), data (e.g., tools to capture, transform, and access data) and selected subjects in fundamental/applied research (e.g., agent-based modeling, search and model building; variable structure simulation; multi-resolution modeling; role of interactiveness in discovery and analysis). Mechanisms must also be established to ensure that the results of these research programs are injected into the practice of M&S.

7. Summary. A great deal of progress in military M&S has been made over the past decade, due in no small measure to the efforts of the Defense Modeling and Simulation Office (DMSO). However, M&S is perceived to be an enabler for incipient revolutions in analysis, acquisition and education and training. It will require institutional initiatives, an evolving family of flexible M&S and a focused research program to realize those revolutions.

Main Report

1. Background. Approximately a decade ago, the Military Operations Research Society (MORS) sponsored a series of three workshops under the rubric of Simulation Technology 1997 (SIMTECH 97). Those workshops focused on identifying and satisfying the simulation technology needs of the analyst in the late 1990s. Ultimately, that activity culminated with a set of findings and recommendations on four major themes: lifecycle management for Modeling and Simulation (M&S); a workstation for the analyst; dealing with "soft factors" (e.g., cognitive factors, performance modulators) in M&S; and responding to M&S's needs for data. In 1997, several of the original organizers of SIMTECH 97 believed that it was an appropriate time to re-assess the results of the prior workshops and to look ten years into the future.

2. Goals and Objectives. The overarching goal of this new series of workshops was to promote more effective dialogue between the M&S technology community and an expanded set of users of M&S: analysts, acquirers and educators and trainers.

Consistent with this goal, four subordinate objectives were identified: review and assess the findings and recommendations from SIMTECH 97; identify and prioritize the needs of the users of military M&S; assess the probable evolution of M&S technology over the next decade; and identify opportunities to address user needs.

3. Approach. To satisfy these goals and objectives, two workshops were convened. The individuals who organized and executed these workshops are identified in Appendix D.2.

The first workshop was conducted at GRCI, Tysons Corner, VA, on 16-18 December 1997. The overall approach to this workshop is illustrated in Figure 1.

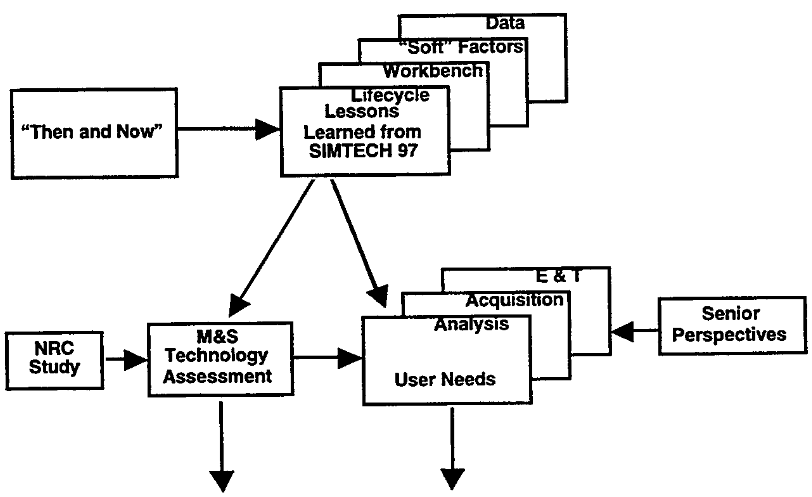


Figure1. Approach to Workshop I

To symbolize the objectives of the workshop, the organizers adopted the JANUS icon; an archetypal GI looking to the past and a cyber warrior looking to the future. Consistent with those

dual perspectives, Ed Brady, FS, Chair of SIMTECH 97, provided a keynote address entitled "Then and Now." That was followed by retrospective assessments by working groups organized around the four major themes that were addressed in SIMTECH 97. To set the stage for assessments of the future, the second day began with plenary presentations on M&S plans and programs[1] in the areas of education and training (Lou Finch, DUSD (Readiness), OSD), analysis (Eric Coulter, PA&E, OSD) and acquisition (Robin Frost, DTSE&E, OSD). In addition, Paul Davis, RAND, provided perspectives on the future of M&S technology by summarizing the major findings and recommendations from a recent National Research Council (NRC) study. Drawing on these presentations and the lessons learned from the retrospective assessments, the participants were reorganized into parallel clusters of M&S users and technologists. The users identified and prioritized the M&S needs of analysts, acquirers and educators and trainers. The technologists formulated a taxonomy for M&S technology and, within that context, forecast conservative and aggressive estimates for the state of M&S technology by 2007.

The second workshop was conducted at the Institute for Defense Analyses (IDA), Alexandria, VA, on 18-20 August 1998. The overall approach to this workshop is illustrated in Figure 2.

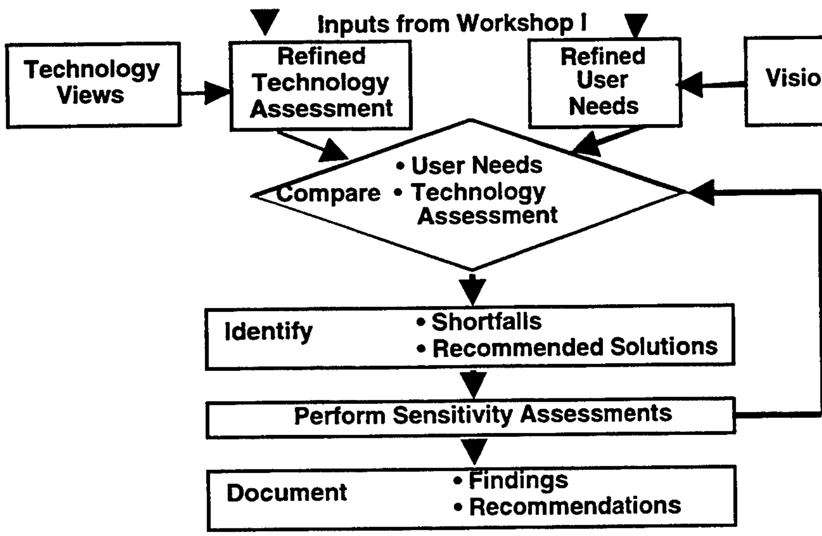


Figure 2. Approach to Workshop II

The workshop began with a keynote presentation by General Larry Welch (USAF, retired), President, IDA, entitled "Some DSB Task Force Perspectives on Simulation for Innovation." His presentation focused on the cultural changes that are required in three dimensions: institutional, M&S and mission orientation. His remarks were followed by a series of plenary presentations on emerging revolutions in education and training (VADM Patricia Tracey, N7, USN), analysis (Vince Roske, Joint Staff), acquisition (Patricia Sanders, DTSE&E, OSD) and a cross-cutting presentation on M&S as an enabler of these revolutions (Vern Bettencourt, FS, AMSO, USA). These briefings were followed by a sequence of M&S technology presentations,

[1] The vugraphs employed by the plenary speakers at both workshops are included in Appendices E to G of these Proceedings. In addition, the affiliations cited for participants reflects their positions when the workshops were convened.

including an overview of the DoD M&S Science and Technology (S&T) program by Gary Yerace, DMSO, and various perspectives on trends in M&S technologies (i.e., Dr Paul Davis on Modeling Methodologies, Dr Richard Nance, VPI & SU, on Design Methodologies, Dr Richard Weatherly, MITRE, on Computer and Communications Capability and Dr Steve Bankes, RAND, on Information Understanding). Drawing on these inputs, hybrid working groups of M&S users and technologists refined their products from Workshop I. Subsequently, these hybrid working groups identified a comprehensive set of shortfalls (subsuming policy, management and technology) and formulated recommendations to ameliorate them. These working groups completed their deliberations by performing sensitivity analyses to explore the robustness of their findings and recommendations to changes in key underlying assumptions (e.g., availability of resources).

4. Products. Four major classes of products were developed during the course of the workshops: lessons learned from SIMTECH 97; key assumptions/drivers for the next decade; M&S technology projections; and top-down assessments from the perspectives of the analyst, acquirer and educator and trainer.

4.1 Lessons Learned from SIMTECH 97. At the first workshop, the participants were charged with reviewing SIMTECH 97 and characterizing its accomplishments and shortcomings. It was concluded that SIMTECH 97 had several notable successes. First, it catalyzed Service investments in M&S. Subsequently, it was a source for the newly created Defense Modeling and Simulation Office (DMSO), which drew upon the workshop's products and participants to create and prioritize its Science and Technology agenda. More broadly, it espoused concepts which helped to shape community perspectives on M&S (e.g., it championed the concept of evolutionary development of M&S vice the classic waterfall development model).

In retrospect, there were several areas in which SIMTECH 97 was less successful. First, while looking out a decade, it made implicit assumptions about constancy which turned out to be false (e.g., it failed to recognize that the Cold War was on the verge of ending). Second, it failed to anticipate several of the emerging technology trends that have had a profound effect upon the M&S community (e.g., the exponential growth in the use of the Internet). Third, in several areas, it gave emphasis to issues which turned out to be of secondary interest (e.g., the role of massively parallel systems). Finally, it formulated several recommendations which were never acted upon adequately and are still valid today (e.g., undertake a research program on "Soft Factors;" initiate a program to acquire, transform, verify, validate and certify data needed by the M&S community).

Based upon this assessment, the workshop participants formulated the following recommendations:

4.1.1 Document key assumptions explicitly. Any attempt to forecast the future involves a host of assumptions. These assumptions should be made clear to the recipient of the report so that they are aware of them and can assess the potential impact if they turn out to be incorrect.

4.1.2 Perform sensitivity explorations. In view of the volatility of the key factors that influence the nature of the problem, it is important to perform sensitivity assessments. This should take the form of explorations of the robustness of findings and recommendations to changes in key assumptions.

4.1.3 Don't generate "point" solutions. In general, the participants concluded that it was better to be approximately right than precisely wrong. Thus, it is recommended that future projections be treated using bounding arguments (e.g., formulate "conservative" and "aggressive" estimates).

4.1.4 Work assiduously to disseminate the workshop findings. In order to enhance the likelihood that the recommendations of a workshop are implemented, it was strongly recommended that the workshop leadership seek to identify and work with a "champion." In the area of M&S, DMSO is an excellent candidate for that role. In addition, many of the recommendations involve communities that transcend the normal MORS membership. Thus, it was recommended that steps be taken to spread the word beyond the "usual (MORS) suspects."

4.1.5 Continue to push for action on key residual recommendations. Several of the participants observed that several of the recommendations made by SIMTECH 97 are still germane today. Thus, substantively, they recommended that efforts be made to implement two of the key SIMTECH 97 recommendations: undertake a coordinated "Soft Factors" research program and initiate a coordinated program to acquire, transform, verify, validate and certify data needed by the M&S community.

4.2 Key Assumptions and Sensitivity Excursions. Consistent with the recommendation from Workshop I, the workshop participants identified key assumptions/drivers for the next decade as a basis for their deliberations. In addition, they identified a set of excursions from these assumptions to support sensitivity assessments (i.e., to explore the robustness of their preliminary findings and recommendations to hypothesized variations in these assumptions). The following section identifies and briefly characterizes those assumptions and sensitivity excursions (see Figure 3).

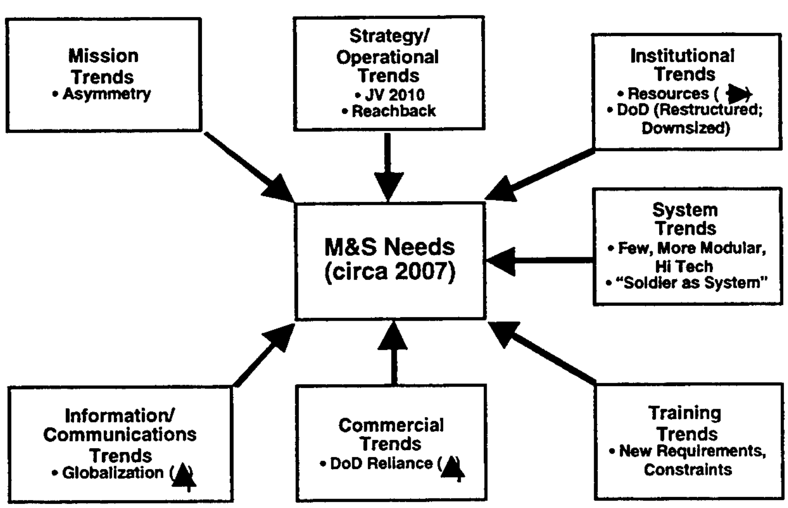


Figure 3. Macro Environmental Assumptions for 2007

4.2.1 Mission. The workshop participants concluded that the likelihood of a major theater war within the next decade is low. However, it was observed that the mission space and its diversity will probably increase. This will probably be manifested in increases in asymmetric warfare, operations other than war, urban warfare, use of weapons of mass destruction, cyberwarfare, and attacks against critical infrastructures. As an excursion for sensitivity analyses, it was postulated that a peer competitor would emerge prior to 2007.

4.2.2 Strategy. The workshop participants projected that the US will continue to pursue the "shape, respond, prepare" strategy articulated in the recent Quadrennial Defense Review (QDR). In addition, the basic precepts underlying Joint Vision 2010 will remain in effect. For example, there will be continuing interest in formulating/experimenting with innovative warfare concepts (e.g., new doctrine, concepts of operations) and efforts will continue to enhance the quality of warfighter information and decrease the time needed to make effective decisions. Consistent with Joint Vision 2010, it was projected that the US military will increasingly be in joint operations with international coalitions of the willing, non-DoD US Government agencies and Non-Governmental Organizations (NGOs). Operationally, it was hypothesized that distributed operations (e.g., reachback) will increase. As an excursion for sensitivity analyses, two alternative outcomes for Joint Vision 2010 were hypothesized: it is perceived as successful (i.e., new joint concepts of operation are adopted) or it is perceived as unsuccessful (i.e., return to more deliberate, mass-oriented operations).

4.2.3 Institutional. The workshop participants identified five key institutional trends for the next decade. First, they projected that the "top line" defense budget will be relatively flat. Hence, the primary opportunity for procurement relief will be to reduce Operations and Support (O&S) costs. In addition, there will be continual pressure to achieve greater efficiency in the DoD acquisition process. Second, military forces will be restructured and downsizing of DoD will continue. Third, CINC responsibilities will continue to evolve. As one example, the roles and missions of USACOM will continue to change as it begins to take a major role in joint experimentation. Fourth, classical institutional "stovepipes" will increasingly merge. As examples, it is anticipated that communities like military operations and training, M&S and Command and Control (C2) will have increasing confluence of interests. Fifth, it is anticipated that senior level decision makers will become increasingly comfortable with M&S and its products. As an excursion for sensitivity analyses, the workshop participants considered alternative futures in which "top line" defense budgets and M&S expenditures might deviate +/- 20% from the baseline.

4.2.4 Systems. The workshop participants identified four macro-trends in the area of military systems. First, it is projected that DoD will continue to emphasize the acquisition of relatively few, high technology, quality systems. This trend will be driven, in part, by the desire to reduce manpower needs. Second, it is anticipated that there will be a broader diversity of systems on the battlefield. For example, Blue forces are likely to be equipped with non-lethal systems and a broader array of unmanned systems. From a Red perspective, it is more likely that adversaries will possess weapons of mass destruction and disruption. Third, there will be a trend towards more modular, "just in time," tailored buying for selected systems. This trend will probably

depend on the success of the concept of Simulation Based Acquisition (SBA). Finally, there will be heightened interest in treating the "soldier as a system." Two cases were selected as excursions from this baseline. First, a variant was postulated in which limited acquisition resources prompt the DoD to plan to retain systems for 50% longer than existing systems. Second, a variant was projected in which DoD shifts to an acquisition strategy that emphasizes more, cheaper (possibly lower tech) systems.

4.2.5 Training. The workshop participants observed that the changing environment implies new training requirements and constraints. In the former case, there is a need for lifelong learning/training; the ability to train effectively with others; more embedded training; more realistic training for stressful environments like night, adverse weather, complex terrain, and nuclear, biological or chemical conditions. In the latter case, training is likely to be constrained by the limited training time available. Alternatively, new technologies will provide new training opportunities (e.g., advanced distributed learning, continuous training opportunities). In view of the limited time available, the workshop participants opted not to consider alternative training assumptions.

4.2.6 Commercial. The workshop participants forecast that DoD will be increasingly reliant on commercial industry for information systems (e.g., proliferated GPS, cellular phones). This commercial technology is projected to turn over more rapidly than every 18-24 months and the commercial supply chain is foreseen to become increasingly globalized. As an excursion for sensitivity analysis, the workshop participants considered the case where DoD's reliance on commercial products proves to be a failure (e.g., commercial products fail to provide adequate environmental robustness or respond adequately to DoD's unique needs), prompting DoD to rely less on commercial products and services.

4.2.7 Information/Communications. The workshop participants projected that information will be increasingly globalized and accessible (via the next generation internet and the emerging global information grid). However, it was observed that concerns will persist about quality and security, information assurance will remain elusive, and Allied and NGO access will remain limited due to security concerns and sensitivities. It was further speculated that the communications infrastructure will continue to put pressure on distributed M&S, particularly for nodes in an active conflict theater. Again, due to limited time availability, the workshop participants opted not to consider alternative assumptions in this area.

4.3 M&S Technology Projections. One of the major products of the workshops was the development and refinement of an M&S technology projection for the next decade. This consisted of three key pieces: a taxonomy, an assessment of the baseline capability and bounding ten-year projections (i.e., conservative and aggressive).

4.3.1 Taxonomy. As a foundation for the technology projection, a taxonomy was developed that can be depicted as a "jigsaw puzzle' with four interlinking pieces (see Figure 4).

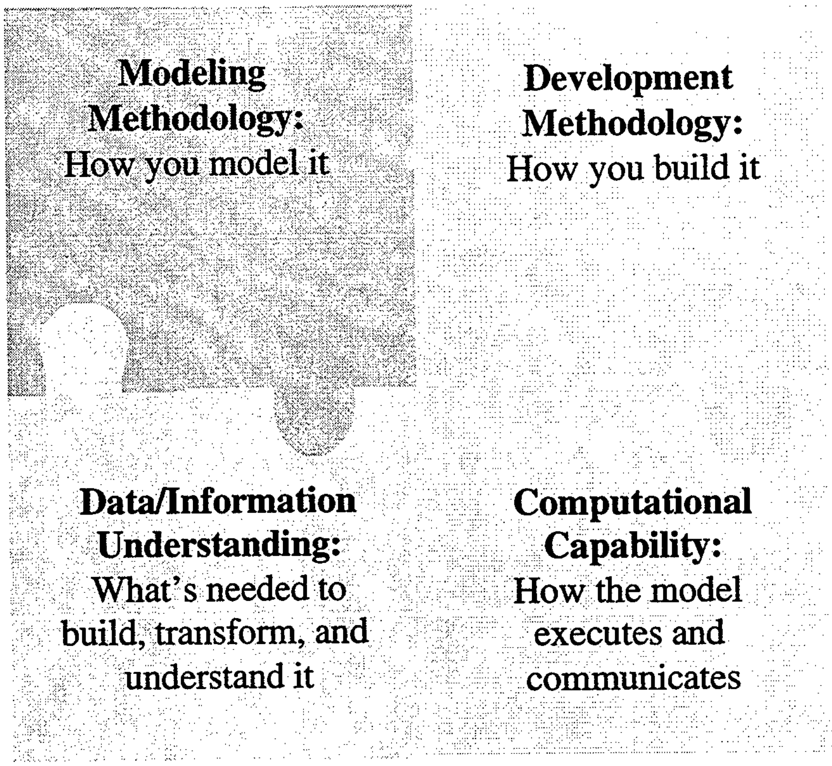


Figure 4. M&S Technology Taxonomy

These pieces include:

- **Modeling Methodology** (How you model it). This includes the theories, processes, algorithms and information that support the conceptualization of a model.

- **Development Methodology** (How you build it). This includes the techniques, tools and software used in the design, construction, and implementation of models or model tool sets.

- **Computational Capability** (How the model executes and communicates). This includes the systems on which the M&S application will be hosted and how the M&S application connects to other M&S applications.

- **Data/Information Understanding** (What's needed to build, transform and understand it). This includes the processes and tools for the capture, storage, transformation and understanding of data and information.

4.3.2 Baseline. As a point of departure, the Technology Working Group used this M&S technology taxonomy to characterize the current state of simulation technology. They arrived at the following assessment.

- **Modeling Methodology.** The most recent focus has been on high resolution, entity-based, human-in-the-loop technologies. There has not been comparable investment in other key technology areas (e.g., Computer Generated Forces (CGF); representation of cognitive processes; tools to analyze, capture and understand requirements). As a consequence, it was concluded that simulations are still too difficult to use and it is extremely challenging to understand the data that are generated from simulations.

- **Design Methodology.** It was recognized by the working group that the design challenges that confront the simulation community are largely the same as those of the software community. Consistent with that observation, it was noted that the complexity of large scale simulation systems is such that they currently exceed the community's ability to specify and build them effectively and efficiently. In addition, standards are still inadequate to support simulation interoperability and reuse. Most of the military community's efforts are focused on the High Level Architecture (HLA) and Synthetic Environment Data Representation and Interchange Specification (SEDRIS).

- **Computational Capability.** The bulk of military simulation needs are not severely constrained by existing computational constraints. Tactical mobile users (with extremely limited communications bandwidths and restricted computational resources) are an exception to that observation.

- **Data/Information Technology.** There are several constraining factors in this area. First, there are few efforts to deal with the full dimensions of the data problem (e.g., acquire, transform, VV&C and warehouse the data needed by the M&S community). Second, scenario generation tends to be a limiting factor, particularly when a large scale simulation is being employed for a theater that has not been previously analyzed. Third, it is recognized that analysis, supported by simulation, is an art vice a science. Thus, the education, skill and experience of the analyst are driving factors. On the positive side, collaboration tools are starting to mature. These tools are beginning to help in the requirements management process.

4.3.3 Selected Technology Projections. For each of the areas of the taxonomy, technology projections were made under conservative assumptions (e.g., continuation of current investment priorities) and aggressive assumptions (e.g., substantial increase in priority with the subsequent likelihood of a breakthrough). The complete set of projections is included in Appendix B.4. To suggest the nature of those assessments, the following section briefly summarizes the projections for selected sub-areas in each of the taxonomy categories.

- **Modeling Methodology.** One of the key sub-areas is representing performance modulators (e.g., representing the effects of "soft factors" such as fear, morale, quality of training, exhaustion). The conservative projection is that the current trend of *ad hoc* treatment of these factors will continue. In that projection, models would be highly uneven in their treatment of such factors. Conversely, an aggressive projection foresaw a state where there would be coherent, community accepted models of these factors. This projection assumed that the SIMTECH 97 recommendation would be ultimately acted

upon and an orchestrated program of "soft factors" R&D would be formulated and resourced appropriately.

- **Development Methodology.** There is a trend towards employing composable technology that will facilitate the development of more "plug and play" M&S. The conservative trend is that there will more use of object oriented technology and that component technology will continue to mature. The aggressive assessment is that composable technology will lead to iconic model construction. Such a trend would lead to true rapid prototyping. Under those circumstances, "boutique" simulation would become viable (i.e., a model builder could rapidly design and implement a new model to reflect the specific issues of interest).

- **Computational Capability.** Networking is a key area that underlies the flexible use of geographically distributed M&S. The conservative projection is that a 10 Gigabit/sec backbone will emerge to support the M&S community within the next decade and network setup will continue to be challenging. The aggressive projection is that a very broad bandwidth backbone will emerge (i.e., on the order of 500 Gigabit/sec) and that network setup is considerably simplified.

- **Data and Information Understanding.** One of the key issues in this area is data capture and storage. The conservative projection is that current policies and processes persist for a decade. Under those conditions, data capture and storage are largely fragmented, *ad hoc* and low priority. The aggressive projection assumes that the SIMTECH 97 recommendation on data is finally implemented. Under those circumstances, one would experience more systematic instrumentation of key events (e.g., advanced warfighting experiments). Consequently, database and data warehouse technologies would continue to mature and be used widely within the M&S community.

4.4 Top-Down Assessments. Fourth, top-down assessments were performed for the functional areas of analysis, acquisition and education and training. These include an articulation of a vision for the functional area; findings, such as an identification of associated needs (in policy, management and technology) and a characterization of perceived shortfalls (e.g., an identification of cases where technology needs exceeded aggressive projections (assessed as "red") and cases where technology needs fell between conservative and aggressive projections (assessed as "amber")); a set of recommendations to ameliorate perceived shortfalls; and sensitivity assessments to establish the robustness of the recommendations.

4.4.1 Analysis Working Group.

Vision. The group defined a vision describing the following operating circumstances of the analyst in 2007. First, multidimensional demands of joint, coalition and international operations will best be met by conducting analysis via teams that mix the right skills and experience to answer pertinent issues. Such teams will match analysts with a broad range of other professionals, including specially trained simulators and communicators. Second, there will be a strong C4ISR component to analytic issues, which the simulations of the day will be better

prepared to address. The growth of a new generation of analytic tools will allow the analyst to focus first on the question of interest, settling on the appropriate tool for the job. Last, in ten years, the analyst will find it easy and normal to work in a distributed analysis environment in direct support of the user, operator and commander.

Findings. Subsequently, priority needs were identified for M&S technology, procedures, models and data.

- **M&S Technology Needs.** Table 1 depicts the Analysis Working Group's assessment of its M&S technology needs. It can be seen that the only area in which the group had confidence that evolving technology would satisfy its needs is in the area of Computing/Communications.

Need	Assessment	Comments
Modeling Methodology		
Representation (Cognitive)	A/R	A limited capability exists only within a restricted domain even under aggressive assumptions.
Representation (Physical)	A/R	A capability exists only for higher resolution models.
Simulation Techniques	A	Dealing with how entities organize themselves into large groups, information flow, networks, aggregation, etc. is a problem.
Requirements	N/A	
Development Methodology		
System Composability	A	
Simulation Frameworks/Composability	A	
Standards	A	The rules for data but not the behavior exist.
Computing/Communications		
Computing Platform	G	Commercial advances will provide adequate DoD capability.
Network Connectivity	G	Commercial advances will generally provide adequate DoD capability.
Security	A	Security remains a risk area.
Data and Information Technology		
Data Acquisition, Capture and Storage	A	Although means to capture data are available, there is no clear process for collecting, storing and sharing data.
Transforming Data	A	Aggregation and disaggregation of data continue to be a major challenge.
Presentation, Understanding and Collaboration	G/A	Presenting analysis results in more than three dimensions is within the state of the art. However, communication of results in terms that the decision maker understands will be a problem.

G: Green, A: Amber, R: Red, N/A: No assessment provided or not applicable

Table 1. Assessment of Analysis M&S Technology Needs

- **Procedural Needs.** First, there is a need for procedural improvements in the area of analytic design. In the future, the analyst should have access to a set of tools that can be adapted or composed to suit the questions at hand. Second, there is a need for analytic procedures that allow detailed exploration of the study space. This concept calls for analyses involving many decision variables (e.g., forces, systems), over a range of several scenarios, with modifications to several parameters within each scenario. Third,

procedures are needed to manage the data collection and analysis of data from events that have some basis in simulation, are low replication (or no replication), but are capable of generating large amounts of data. These procedures respond to the present requirement to conduct "experiments" or "demonstrations" to support decision making or program development activities. This need also involves a combination of data analysis techniques and database management tools to facilitate handling the data. Fifth, there is a need is to provide specialized training and continuing "mentoring" to analysts in the techniques necessary to execute these more complex analyses. Finally, there is a need to continue development of theory for new scientific approaches to military problems.

- **Model Needs.** The needs for models parallel those for analytic procedures and also address issues of expanding analytic challenges. The highest priority need is for a full spectrum of tools that allow the analyst to structure the analysis to fit the issue and then compose or select the models and tools that are appropriate. The spectrum of tools must include models and tools for warfighting and non-warfighting missions. To complete the spectrum, more specialized tools are required, including robust C4ISR models, models for information warfare, models with non-lethal effects and models that address non-combat targets.

- **Data Needs.** Many improvements are also necessary in the area of data support. First, it is necessary to institute a comprehensive management process for data management, which includes identifying responsible organizations for data production and management. Second, there is a need for productivity tools, including scenario generation tools. The objective of these tools is to reduce the long number of weeks required to assemble the typical scenario from scratch. Third, there is a need for enabling technologies for the extraction and analysis of useful data needs from "real life" — including warfare, exercises and experiments like the Army Warfighting Experiments (AWEs) and Advanced Concept Technology Demonstrations (ACTDs). Fourth, a "help desk" is desired in order to provide efficient access to these improved capabilities. Fifth, there is a need for advanced mining tools to make it possible to derive relationships across databases or inferentially from data. Sixth, the next development desired is intelligent agents that assist in generating specialized data. These agents, triggered by situations encountered in the course of a model run, would act to gather detailed data relating to cause and effect, providing greater clarity and insight for the analyst. Data processing procedures to allow the specification of desired measures — and then to generate appropriate data — is a further extension of the desired data capabilities. Finally, there is a need for a stronger ability to extract information from data, including visualization tools and processes for dealing with chaotic behavior.

Recommendations.

- **Education.** Establish a formal educational course that trains analysts in the techniques and processes involved in complex analysis. Moreover, since capabilities will continue to emerge and be refined, a continuing education process is recommended to keep analysts qualified in the latest techniques.

- **Research.** In order to continue the advancement in analysis, establish a program of continued research that addresses both military phenomenology and scientific advancement.

- **Experimentation.** Underpin AWEs and ACTDs with an analytic process to derive valid conclusions and usable data. This process includes both a solid structure to define the experiments and analytic procedures to extract valid insights from the volumes of data generated. To support some of the capabilities already described, intelligent agent technology should be pursued.

- **Dealing With Complexity.** Develop educational approaches that highlight the ability to design a complex, highly dimensional analysis, to execute it in a distributed fashion, and to conduct a thorough analysis of the outputs. While the tools of experimental design, stochastic modeling and computer science will fill much of the need, education and practice in a focused curriculum will result in a more responsive, innovative analysis.

- **"New Sciences."** Invest further effort in pursuing and developing the "new sciences" and teaching their theory and application to new practitioners to usage in appropriate places. The potential of these "new sciences" is strong, but they need to be focused on profitable applications.

4.4.2 Acquisition Working Group.

Vision. In the vision of this group, acquisition will address total life cycle support, instead of merely the initial phases of concept development, design, development and manufacturing. Consistent with this focus, DoD will commit to life cycle cost as the basis for making acquisition decisions. In addition, DoD and industry will use collaborative, robust environments supported by simulation technology.

Some important characteristics are envisioned for the Simulation Based Acquisition (SBA) end state. First, more of the development responsibility will shift to industry. Second, partnerships that permit the sharing of data and models will be developed that have trust as a cornerstone of the relationship. Third, a highly integrated, electronic environment will be developed and employed across all life cycle functions to permit the early and continuous visibility and evaluation of system development alternatives. Last, DoD will adopt commercial practices, as appropriate, to reduce production times that are much shorter than the typical 10-15 year period.

Findings. To implement that vision, major changes must occur in culture, management, policy and technology/environment. Cultural changes, especially the move to greater reliance on M&S to reduce costs, are very important. There must be integration across Services and domains. A way to foster trusted government-industry partnership to promote pervasive sharing of models and data must be found. This last change will not be achieved by dictate but will necessitate an incentive for sharing.

The Acquisition Working Group formulated the following additional major findings. First, there is a lack of personal and programmatic reward for adhering to SBA tenets. Second, there is inadequate upfront investment to implement SBA. Third, there is an absence of investment in the adoption or translation of the best products or lessons learned from other programs and in the underlying technology, not by individual programs, but rather by concerted programs. Fourth, there is a lack of guidance on M&S use in formal acquisition decisions and current policy limits on effective use (immediate use of current technology) of commercial domestic and international products and services. Next, there is a lack of adequate stewardship for M&S tools, standards and data as well as for M&S education and training. Last, there is wide disparity in the extent to which M&S technology will affect the implementation of the SBA paradigm.

As can be seen in Table 2, modeling methodologies are the most serious shortfalls that require high priority for funding.

Need	Assessment	Comments
Modeling Methodology		
Representation (Cognitive)	A/R	Significant attention is required to achieve goals.
Representation (Physical)	A	Some gaps (e.g., durability models) still exist.
Simulation Techniques	A/R	No serious efforts are underway to mature new techniques.
Requirements	A	The role of M&S in understanding system requirements is unclear.
Development Methodology		
System Composability	A	The software community is driving this need.
Simulation Frameworks/Composability	G/A	
Standards	A	No standard for an integrated data environment exists.
Computing/Communications		
Computing Platform	G	
Network Connectivity	G	
Security	G/A	Potential problems exist in protecting data.
Data and Information Technology		
Data Acquisition, Capture and Storage	G/A	Basic tools exist.
Transforming Data	G/A	Although underlying technology exists, implementations do not.
Presentation, Understanding and Collaboration	G	Additional automation would be useful. Ability to tie scenario goals to results is not adequate.

G: Green, A: Amber, R: Red, N/A: No assessment provided or not applicable

Table 2. Assessment of Acquisition M&S Technology Needs

Recommendations

- **Program Objective Memoranda (POM) Investments.** Establish and support sufficient M&S-infrastructure investments in the POM as the norm to reduce life-cycle costs.

- **Policy/Guidance.** Establish policy and guidance on: M&S use throughout the entire formal acquisition decision process; utilization of emerging commercial domestic and international products and services to maximize SBA potential; and guidance on a common implementation for sharing M&S and data between government and industry. As part of this policy, provide incentives to all the stakeholders, including the program mangers who use these M&S methods properly for reducing life cycle costs.

- **Institutional.** Establish a single empowered entity, not a council or a policy organization, to manage SBA. Promote SBA partnering at many levels (e.g., the top level through M&S Executive agents working with industry conglomerates).

- **DoD M&S Master Plan.** DMSO should identify model representations as a priority in the next DoD M&S Master Plan. The CGF community should reprioritize and put effort into new simulation techniques. DoD should work to resolve level of abstraction difficulties and establish links between Computer Aided Design/ Computer Aided Manufacturing (CAD/CAM) and operational effectiveness.

4.4.3 Education and Training Working Group

Vision. The working group envisioned a future in which individuals will be educated on "how to learn." Subsequently, those individuals will receive training (i.e., "how to do") that is just-in-time, just enough, tailored to needs and delivered when and where needed. Consistent with that vision, education and training will be integrated, capitalize on research and leverage non-DoD technology advances. In addition, analysis, acquisition and education and training will provide mutual support and exploit common resources.

Findings. First, education and training will play a more significant role than ever before because of profound changes in the world. In particular, education and training will be needed to support all of the innovative Service programs (e.g., Army After Next, Alternative Air and Space Forces), subject to the constraints of significant force drawdown, increased PERSTEMPO and OPTEMPO and increased breadth of operations.

Second, fewer resources for implementing education and training will be available because of the downsizing trend across DoD.

Third, as a major paradigm change, "just-in-time/just-enough training," distributed when and where required, will become an increasingly important and prevalent component of training. In effect, the responsibility for learning will shift from the institution to the individual and will require a significant focus on teaching "how to learn" and thus an increased focus on the science of education. A fully integrated, constantly available education and training system will provide "pull" as well as "push" — fully supporting meeting the goals of Joint Vision 2010. The goal is to transition today's classroom focused education process and unstructured hands-on training into a continuously available distributed system composed of courses and on-line knowledge bases that can be pulled by the "life-long student" as required, giving each individual the resources to become an "expert" when needed.

Fourth, the training and education process will be significantly different because the rapid evolution of technology will tend to make detailed, long-to-develop training and education plans obsolete before they can be implemented. Technology changes demand a rapid, flexible process that can educate the warfighter quickly and satisfy a variety of technical capabilities.

Fifth, the advent of new technologies will have the potential to revolutionize the training and education process. Distance Learning (DL) and Advanced Distributed Simulation (ADS) tools will be able to place a user in contact with geographically dispersed knowledge bases and provide new sets of simulation tools that may speed learning and improve retention. Web-based technologies such as Java will help to provide ease of application sharing across platforms that will lead to improvements in DL and ADS. Advances in Artificial Intelligence (AI) hopefully will lead to improvements in human behavioral representation — a key to improving interactive training with simulations.

Finally, M&S technology shortfalls are broadly consistent with those identified by the other functional areas (see Table 3). In general, the least constraining areas are projected to be in the areas of Computing/Communications while the most constraining areas are foreseen in Modeling Methodology.

Need	Assessment	Comments
Modeling Methodology		
Representation (Cognitive)	R	No viable HBR theory exists.
Representation (Physical)	R	Societal effects (e.g., political, economic and social) need to be modeled.
Simulation Techniques	R	No complete theory for HBR exists
		No DoD Program is in place
Requirements	A	DoD influence is necessary
Development Methodology		
System Composability	A	
Simulation Frameworks/Composability	A	
Standards	A	The technology for common infrastructure and standard interfaces to plug and play exist, but operations is a problem.
Computing/Communications		
Computing Platform	G	
Network Connectivity	G	
Security	A	
Data and Information Technology		
Data Acquisition, Capture and Storage	A/R	An infrastructure and mechanisms to retrieve information needs to be created. No theory exists for the collection of data.
Transforming Data	G/A	
Presentation, Understanding and Collaboration	G/R	HCI is not standard across military systems. No training theory exists.

G: Green, A: Amber, R: Red, N/A: No assessment provided or not applicable

Table 3. Assessment of Education and Training M&S Technology Needs

Recommendations. The Education and Training Working Group formulated recommendations in six areas: training methods, needs assessment, "come to the people," individual responsibility, life-long process and cross-functional sharing.

- **Training Methods.** Develop new methods of training in applying the new technologies. DoD must adopt methods that will help change the **way** people learn in addition to **what** they learn. New learning methods that stress the ability to assimilate information will likely be required, instead of traditional methods that focused on memorization or repetition.

- **Needs Assessment.** Conduct a periodic "Needs Assessment." This assessment will: (1) identify shortfalls in the training and education domains; (2) prioritize these needs and fund efforts to correct them via an implementation plan; and, (3) develop a feedback process that will periodically revise this implementation plan.

- **"Come to the People."** Make the education and training process significantly more efficient to deal with the consequences of the smaller forces (downsizing), the increased OPTEMPO/PERSTEMPO, and the increasingly complex world. This training/education process must come to the people, and not the people to it. It may be prudent to oversee the application of DL and ADS through the formation of a program office that can coordinate the implementation across all of DoD (i.e., implementation of the advanced distributed learning initiative).

- **Individual Responsibility.** Individuals must take more of the responsibility for training and educating themselves. In support, DoD must adopt a policy that will provide incentives for individuals to improve themselves through education and training. Likewise, institutions must share in this process so that available resources are not squandered.

- **Life-long Process.** Implement a life-long education and training process because the world is rapidly changing, the rapid evolution of technology often makes knowledge obsolete within only a few years, and each person needs to be proficient in more skills (fewer people engaged in more complex work). In support of this process, personnel systems must accommodate the need for continuous training throughout the career cycle. To facilitate this process, broad-based training must be integrated with specific, tailored training throughout a soldier's career. Links to non-military institutions of higher learning (e.g., universities, community colleges) will be necessary to expand the knowledge base for such information. In addition to the requirements for changes to be made in training and education systems, numerous policy changes are needed to stimulate technology changes. Finally, it is important to focus on how to utilize emerging technologies and gain experience in applying them.

- **Cross-Functional Sharing.** To the extent possible, the Executive Committee for Modeling and Simulation (EXCMS) should focus on removing the redundancies in applications of simulation across the training, analysis and acquisition areas of DoD and leverage off similar efforts. It is recognized that some efforts in these domains are unique and cannot be leveraged, but they may be able to utilize common core M&S pieces.

In addition, management of the analysis, acquisition and training domains must be done in such a way that they may share common resources when necessary. Such examples might include the sharing of simulators (e.g., performing virtual prototyping in the acquisition domain, determining requirements in the analysis domain and training operators in the training domain). Data must be easily accessible and shared across domains, without the traditional concerns of releasability of data.

5. Selected Cross-Cutting Findings. Each of the plenary speakers at the second workshop identified M&S as a key enabler to promote revolutions in analysis, acquisition and education and training. This hypothesis was validated by all of the working groups.

Several of the plenary speakers observed that many of the obstacles to these revolutions are cultural in nature. Among the more important cultural obstacles identified were institutional barriers (e.g., the need to go from "stovepiped" organizations to more collaborative organizations that would promote the more efficient sharing of tools, data and expertise); modeling and simulation barriers (e.g., transitioning from the inflexibility of current M&S to more flexible M&S to explore easily new operational concepts, doctrines, procedures and the human dimension); and process barriers (e.g., transition from the use of a few, "blessed" scenarios to a full range of scenarios that span the mission space). Again, these observations were extended and validated by all of the working groups.

From a technology perspective, the working groups concluded that the most significant shortfalls were projected to occur in modeling methodology (i.e., adequate representation of key cognitive factors, performance modulators, and computer generated forces); development methodology (i.e., system architecture/engineering; system composability, scalability; and standards for design, interoperability and reuse); and data/information understanding (i.e., tools for dealing with data acquisition, transformation and access; tools to support collaboration) [see Figure 5].

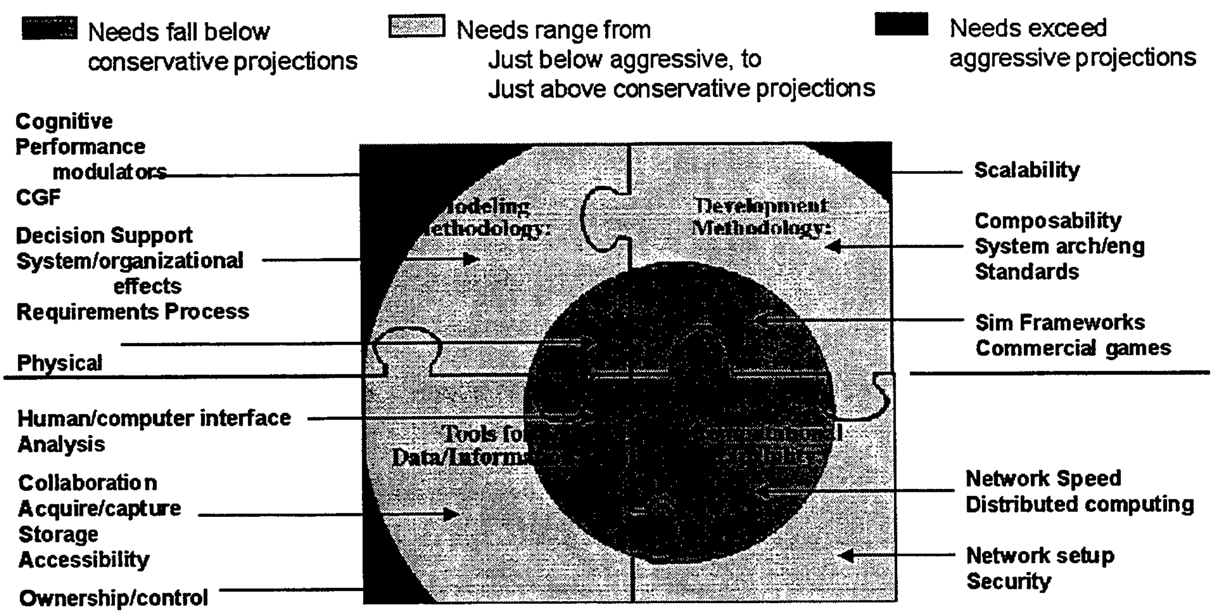


Figure 5. Aggregate Comparison of User Needs and Technology Projections

In almost all cases, these projected technology shortfalls cut across individual functional areas. It is notable that each functional working group also opined that commercial developments in

communications and computing would probably not constrain M&S applications, with the exception of security needs.

6. Cross-Cutting Recommendations. Consistent with the selected findings, the following cross-cutting recommendations have been formulated.

6.1. Institutional Initiatives. To facilitate the development of a better balanced M&S Science and Technology (S&T) investment strategy, it is necessary to develop a clear, comprehensive audit trail for current M&S S&T programs and plans.

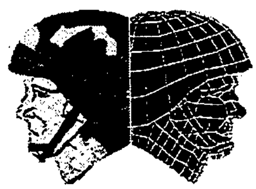
To promote needed community sharing of tools, data and expertise, organizational focal points are required for SBA and Advanced Distributed Learning (ADL). These organizations should champion these processes, promote pilot programs, monitor commercial developments, begin to establish the community infrastructure needed to "boot strap" the processes and assure the full scope of cross-cutting activities are undertaken (e.g., ensure that education and training needs are treated adequately in SBA).

6.2. Program Initiatives. An expanded family of flexible, readily tailorable M&S is needed to address many user needs. Although on-going monolithic model developments (e.g., JWARS, JSIMS) will probably prove to be central elements of this family, they will almost certainly not be sufficient to satisfy the needs of all users. To complement them, "boutique" models are needed that address all aspects of the expanding mission space (e.g., asymmetric conflict; new operational concepts). These include system dynamics models (to provide the ability to quickly scan and pre-filter scenario space) through virtual M&S (to capture the effects of distributed teams of people under stress). In particular, the demands of AWEs mandate new classes of M&S, which are sufficiently flexible to explore easily new operational concepts and companion education and training experimentation plans to address the subjects' needs for associated training.

6.3. Research Initiatives. To redress identified M&S technology shortfalls that affect all users of M&S, undertake organized research programs in "soft factors" (e.g., cognitive factors, performance modulators, computer generated forces), data (e.g., tools to capture, transform, and access data), and selected subjects in fundamental and applied research (e.g., agent-based modeling, search and model building; variable structure simulation; multi-resolution modeling; role of interactiveness in discovery and analysis). Mechanisms must also be established to ensure that the results of these research programs are injected into the practice of M&S.

7. Summary. A great deal of progress in military M&S has been made over the past decade, due in no small measure to the efforts of DMSO. However, M&S is perceived to be an enabler for incipient revolutions in analysis, acquisition and education and training. It will require institutional initiatives, an evolving family of flexible M&S, and a focused research program to realize those revolutions.

Simulation Technology 2007 (SIMTECH 2007): Overview



16-18 December 1997 (GRCI)
18-20 August 1998 (IDA)

Agenda

- Goals and Objectives
- Approach/Participants
- Key Products
- Overarching Findings/Recommendations

Goal

- **To promote more effective dialogue between the**
  - Modeling and Simulation (M&S) technology community
  - Users of M&S
    - analysts
    - acquirers
    - educators and trainers

Objectives

- **Retrospective**
  - Review and assess the findings and recommendations that were made by the participants at SIMTECH 97

Objectives

- **Retrospective**
  - Review and assess the findings and recommendations that were made by the participants at SIMTECH 97

- **Looking forward**
  - Identify and prioritize the needs of the users of military M&S
  - Assess the probable evolution of M&S technology over the next decade
  - Identify potential user shortfalls (e.g., policy, management, technology) and recommend actions to ameliorate them

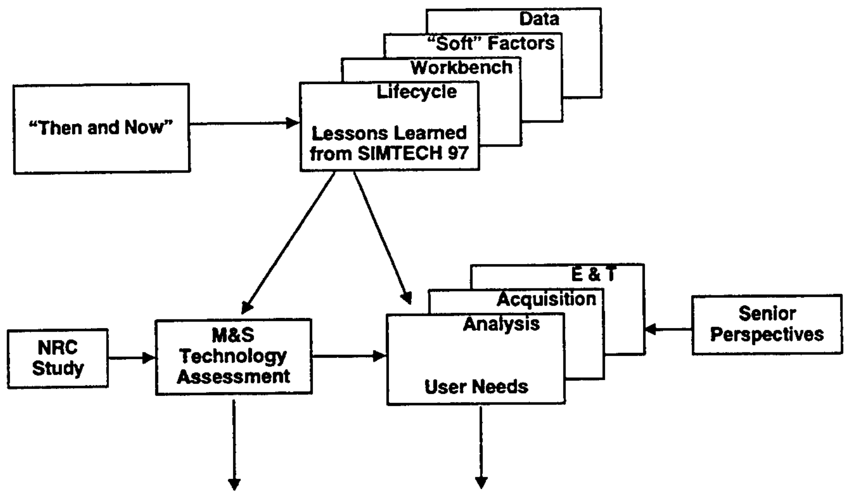
MORS

Agenda

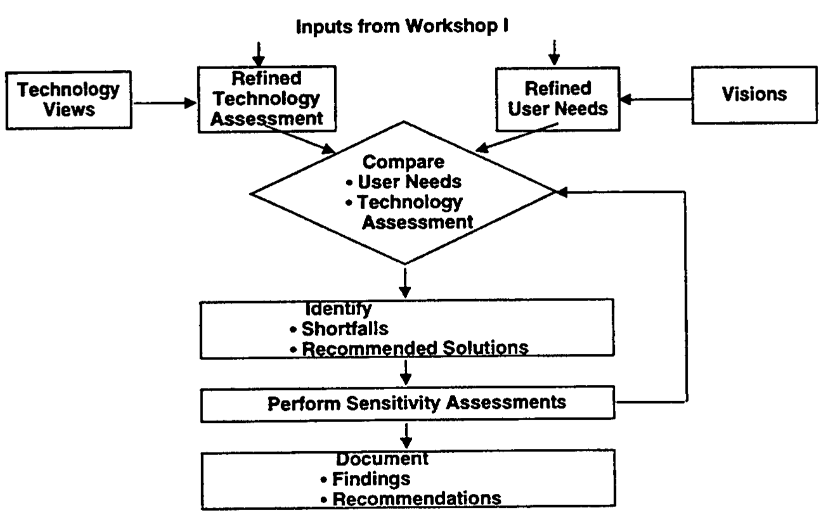
- **Goals and Objectives**
- **Approach/Participants**
- **Key Products**
- **Overarching Findings/Recommendations**

MORS

Approach: Workshop I



Approach: Workshop II



Workshop Organizers

Position	Name	Affiliation
Chair	Stuart Starr	MITRE
Co-chairs	Howard Carpenter	MITRE
	Denis Clements	GRCI
	Lana McGlynn	DAMO, USA
	Bob Orlov	J-8, JS
	Bob Statz	BAH
MORS "Bulldog"	Col "Crash" Konwin	DMSO

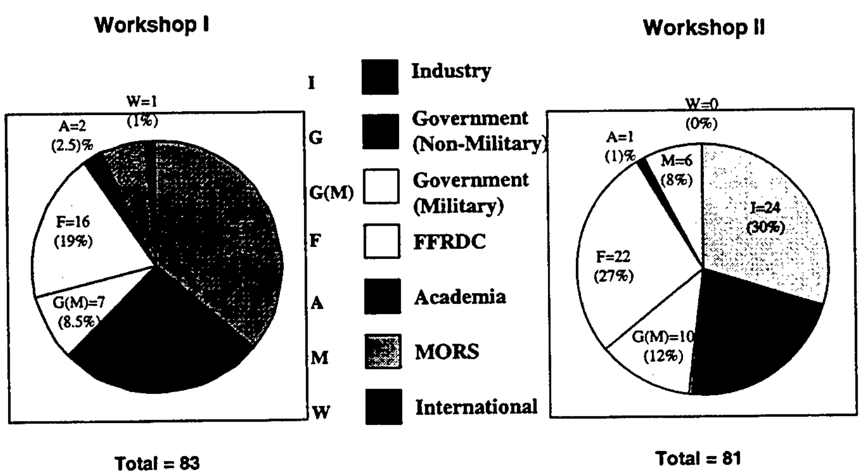
Plenary Speakers

Speakers	Workshop I	Workshop II
Keynote	Ed Brady, SPI	Larry Welch, IDA
Plenary	Lou Finch, OSD	VADM Pat Tracey, USN
	Eric Coulter, OSD	Vince Roske, Joint Staff
	Robin Frost, OSD	Pat Sanders, OSD
		Vern Bettencourt, FS, AMSO, USA
	Paul Davis, RAND	Gary Yerace, DMSO
Panel		Paul Davis, RAND
		Dick Nance, VPI
		Richard Weatherly, MITRE
		Steve Bankes, RAND

Working Group Leadership

	Theme	Leadership
Retrospective	Life Cycle Management	Bruce Bennett, RAND Bob Statz, BAH
	Analyst Workbench	Iris Kameny, RAND John Gilmer, Wilkes University
	"Soft" Factors	Dick Hayes, EBR Lashon Booker, MITRE
	Data	Phil Dickinson, Consultant Carl Russell, JNTF
Looking Forward	Analysis	Cy Staniec, Logicon Hank Dubin, OPTEC Russ Richards, MITRE Mark Youngren, MITRE
	Acquisition	Gary Jones, DARPA Dick Helmuth, SAIC Annie Patenaude, SAIC Dell Lunceford, DARPA
	Education and Training	Phil Abold, A&B Technology Zach Furness, MITRE Julia Loughran, Thoughtlink
	Technology Assessments	Dell Lunceford, DARPA Denis Clements, GRCI Julia Loughran, Thoughtlink
	Synthesis	Paul Davis, RAND Clayton Thomas, FS, USAF

Workshop Participants



Agenda

- Goals and objectives
- Approach/participants
- Key products
  - Lessons learned from SIMTECH 97
  - Key drivers/assumptions
  - Technology projections
  - Functional assessments
- Overarching findings/recommendations

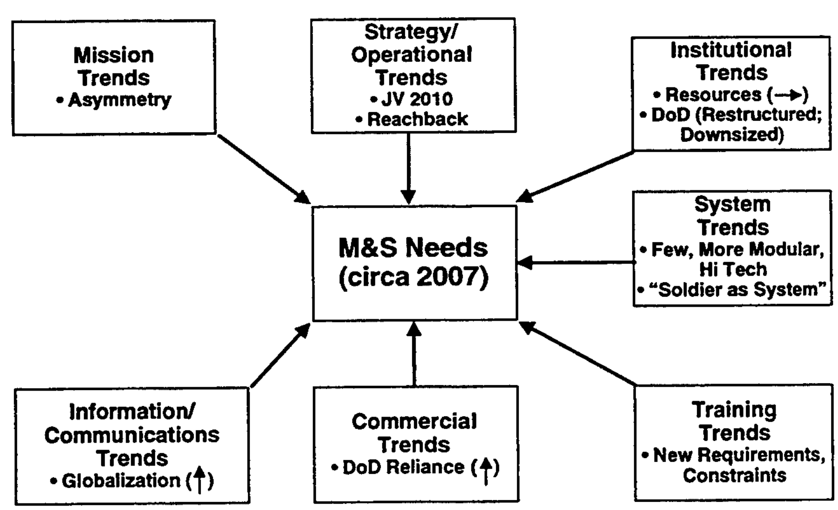
What Did SIMTECH 97 Do Well/Less Well?

- Did well
  - Helped set the Science and Technology (S&T) agenda for DMSO, focus Service investments
  - Helped shape community perspectives on M&S (e.g., view lifecycle management as an evolving process)
- Did less well
  - Made an implicit assumption of constancy, without adequate sensitivity exploration
  - Failed to anticipate key changes; e.g.,
    - Geopolitical (e.g., end of Cold War)
    - Technological (e.g., exponential growth of Internet; DoD-commercial software spin-off/spin-on process)
  - Gave excessive emphasis to subordinate issues (e.g., massively parallel systems)

Selected Recommendations (Based on Retrospective Look)

- Document key assumptions more explicitly
- Perform sensitivity explorations
- Don't generate "point" solutions (i.e., it is better to be approximately right than precisely wrong)
- Work assiduously to disseminate the workshop findings, recommendations; e.g.,
  - Identify, work with a "champion" (e.g., DMSO)
  - Spread the word beyond the "usual (MORS) suspects"
- Continue to push for action on key residual recommendations; e.g.,
  - Undertake "Soft Factors" research program
  - Systematically collect and "transduce" data from key targets of opportunity (e.g., AWEs, ACTDs)

Macro Environmental Assumptions for 2007



Selected Sensitivity Excursions

- **Mission trends**
  - A peer competitor emerges prior to 2007
- **Strategy/operational trends**
  - Joint Vision 2010 is perceived as unsuccessful (i.e., return to more deliberate/mass oriented operations)
- **Institutional trends**
  - "Top line" defense budget: +/-20% from the baseline
- **Systems trends**
  - Limited acquisition resources prompts the DoD to plan to retain systems for 50% longer than existing systems
  - DoD shifts to an acquisition strategy that emphasizes more, cheaper (possibly lower tech) systems
- **Commercial trends**
  - Reliance on commercial products proves to be a failure, prompting DoD to rely less on commercial products, services

Guidance - "Out of the Box" Technology Assessment

Technology WG: Approach

- **Taxonomy**
  - Several taxonomies for structuring the M&S technology assessment problem were formulated and applied
  - Ultimately, it was elected to employ a taxonomy structured around the concept of a "jigsaw puzzle" (as seen below)
- **Assessments**
  - Within the context of the taxonomy, two technology assessments were performed for the year 2007
    - Conservative predictions assume that the area maintains its current priority and funding in the area is consistent with currently programmed resources
    - Aggressive predictions assume that the area receives a substantially higher priority and funding in the area is increased accordingly

M&S Technology Taxonomy

Modeling Methodology:
How you model it

Development Methodology:
How you build it

Data/Information Understanding:
What's needed to build, transform, and understand it

Computational Capability:
How the model executes and communicates

Technology Areas

- **Modeling methodology: The theories, processes, algorithms and information that support the conceptualization of a model**
- **Development methodology: The techniques, tools and software used in the design, construction and implementation of the models or the model tool set**
- **Computational/communications capability:**
  - What the M&S application will be hosted on
  - How it connects to other M&S applications
  - How M&S application developers and users connect to one another
- **Data/information understanding: The tools and processes for data capture, storage, transformation and understanding:**
  - How to acquire and store the data
  - How to transform it (e.g., scenario generation)
  - How to understand the data (including HCI factors and information understanding techniques)
  - How to collaborate about it

Current State of Simulation Technology

- **Modeling methodology**
  - Most recent focus on high resolution, entity based, human-in-the-loop technologies; little real investment in other areas
  - Few to no advances in Computer Generated Force (CGF) technology
  - Simulations still too hard to use, too hard to understand results
- **Design methodology**
  - Simulation = software; many of the development challenges of one are the challenges of the other
  - Large scale simulation system complexity exceeds community's ability to build
  - Standards efforts currently (esp. for interoperability/reuse) limited to HLA and SEDRIS; most standards in use 'owned' by commercial sector
- **Computational capability**
  - A limiting factor, but not by much for bulk of simulation needs
- **Data/information technology**
  - Few efforts to instrument/collect raw data
  - Scenario generation a limiting factor
  - Analysis an art, not a science
  - Collaboration tools maturing; beginning to help requirements management

Selected Technology Projections

Area	Sub-Area	Conservative	Aggressive
Modeling Methodology	Representing Performance Modulators	• Approaches remain *ad hoc*	• Coherent, community-accepted models*
Development Methodology	Composable Technology	• More use of Object Oriented Technology • Maturing of component technology	• Development leads to iconic model construction • True rapid prototyping/"boutique" simulation becomes viable
Computation and Comms	Network	• 10 Gigabit backbone • Network setup continues to be difficult	• 500 Gigabit backbone • Network setup is considerably simplified
Data and Info Understanding	Data capture, Storage	• Continues to be —Fragmented —*Ad Hoc* —Low priority	• More systematic instrumentation of events* • Database, data warehouse technologies mature

* Assumes SIMTECH 97 recommendations are implemented

Guidance to the Functional Working Groups

- **Formulate your vision for the future (on how M&S can enhance effectiveness, efficiency)**
- **Identify the key drivers that influence your needs**
- **Identify and prioritize needs to achieve the vision in the areas of**
  - Policy
  - Management
  - Technology
  - Other
- **Provide recommendations to address high priority needs**
- **Perform sensitivity analyses to assess the robustness of your recommendations**

Education and Training Vision

- **What**
  - Educate on "how to learn"
  - Train ("how to do")
    - just-in-time
    - just enough
    - tailored to needs
    - delivered when, where needed
- **How**
  - Education and Training will
    - be integrated
    - capitalize on research
    - leverage non-DoD technology advances
  - Analysis-acquisition-education/training will
    - provide mutual support
    - exploit common resources

Key Drivers: Education and Training (E&T)

Mission Trends
- Expanded mission space
- Changed ACOM mission

Strategy/Operational Trends
- Increasing
  - Operations space
  - Decision space
- Reduced decision time
- Increased reachback operations

E&T M&S Needs

Training Trends
- Environmental changes imply new E&T
  - Requirements (e.g., need for lifelong learning/training; ability to train with others)
  - Constraints (e.g., limited time to train)
- New technologies pose new opportunities
  - Advanced Distributed Learning (ADL)
  - Continuous training opportunities

Institutional Trends
- Downsizing of force
- Merging of classical stovepipes
  - Operations, training
  - M&S, C^2

Key E&T Technology Needs

Area	Need	Assessment
Modeling Methodology	• Improve behavioral representation	R
	• Broaden representation of societal effects (e.g., political, social, economic)	R
	• Adapt to personal learning style/distributed learning	R
Development Methodology	• Create/adopt open architectures which allow integration of COTS/GOTS products	A
	• Create a common infrastructure and standard interface to support "plug and play"	A
Computing/ Communications	• Address security issues	A
Data and Information Technology	• Data/information acquisition (including operator, system instrumentation)	R
	• Standardization of HCI across military systems	R

*Legend:

Symbol	Meaning
Red (R)	Needs exceed aggressive projection
Amber (A)	Needs range from - Just below aggressive to - Just above conservative
Green (G)	Needs fall below conservative projection
None (N/A)	Not applicable

Key Education and Training Recommendations

- **Institutional: Incorporate E&T into:**
  - Simulation Based Acquisition
  - Joint Experimentation Program
- **Research: DDR&E should establish a research program to**
  - Capture and extend theory on
    - "how we learn"
    - "how to teach"
  - Develop human performance measures/metrics to support E&T evaluation
  - Capture, store, and make accessible information on
    - individual and organizational performance
    - E&T system performance
  - Create a comprehensive program on human behavior representation

Analysis Vision

- **What**
  - Analysts will have the ability to address a broad range of problems (e.g., joint/interagency/coalition), with timely, accurate and relevant insight and information
- **How: Analysts will work**
  - In distributed, interdisciplinary teams; e.g., analysts, M&S experts, C4ISR experts
  - In support of commanders and decision makers at all levels (wherever they are)
  - Either directly or through powerful new analyst-developed
    - tools
    - decision aids
    - data bases

Key Drivers: Analysis

Mission Trends

- Broader Spectrum (e.g., OOTW/Urban/MTW)
  - In some cases, US military as support to main mission
  - Selectively, non-lethal objectives
- Emerging threat concerns
  - Asymmetric warfare
  - RMA
  - WMD

Strategy/Operational Trends

- Guided by precepts of JV2010
  - Speed
  - Synchronization of efforts
  - Quest for Information Dominance
- US military will increasingly be in operations with others
  - Joint
  - Coalition
  - Inter-Governmental
  - NGOs

Analysis M&S Needs

Institutional Trends

- Decision making supported by
  - ATDs/ACTDs
  - AWEs
  - SBA

Analysis Recommendations (1 of 2)

- **Tool chest**
  - Create, sustain M&S that treat C4ISR explicitly to deal with all operations of interest, particularly
    - OOTW
    - New concepts of warfare; e.g.,
      - Split base operations
      - Network centric warfare
      - Information warfare
      - Small unit operations
      - Non-lethal weapons
  - Augment existing tools with the latest
    - Conceptual thinking (e.g., complexity theory)
    - Techniques (e.g., agent modeling, genetic algorithms)
  - Incorporate new features; e.g.,
    - Intelligent agents to "bookmark" key events to facilitate "what if…" analyses
    - Better visualization capabilities
    - Data mining, knowledge discovery tools

Analysis Recommendations (2 of 2)

- **Procedures**
  - Create the ability to design analyses to suit issues
  - Ensure that analysts explore "study space" fully
  - Transform "demonstrations" into "experiments" (e.g., AWEs)
  - Enhance capability to analyze large volumes of complex data effectively
  - Undertake a research program to develop new scientific approaches to military problems
- **Data**
  - Institute a comprehensive process for data management
  - Develop technologies for extraction and analysis of:
    - useful data from events (e.g., intelligent agents)
    - information from data (e.g., visualization tools)
  - Establish a "Help Desk" for data
- **People**
  - Educate/train/mentor analysts on the the new procedures, tools, data management/technologies

Acquisition Vision

- What
  - Reduce
    - time
    - resources
    - risk
    - total ownership costs throughout life cycle process
  - Increase
    - quality
    - military worth
    - supportability of fielded systems
- How
  - Enabled by simulation technology that is
    - Robust
    - Used collaboratively
    - Integrated across life cycle phases, functions and programs

Acquisition Recommendations (1 of 2)

- Policy
  - Establish policy/guidance on the use of M&S in formal acquisition decisions
  - Define a policy to utilize emerging commercial domestic and international products, services to maximize Simulation Based Acquisition (SBA) potential
  - Establish DoD policy and a common implementation for sharing M&S and data
- Organizational
  - Identify and empower an organization to enable
    - dedicated, enduring pilot and flagship programs
    - stewardship for managing SBA

Acquisition Recommendations (2 of 2)

- **Institutional**
  - Establish and support sufficient M&S infrastructure investments in the POM
  - Provide incentives to all stakeholders, accompanied by adequate up front investment, for use of M&S early and throughout the life cycle
- **Technology**
  - Ensure that the next DoD M&S Master Plan highlights key SBA needs
    - improved representation of emerging warfare areas, cognitive factors
    - enhanced CGF
    - standards for design, interoperability (i.e., links between CAD/CAM and operational effectiveness M&S to support "what if..." trades)

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Agenda

- **Background**
- **Goals and Objectives**
- **Approach**
- **Key Products**
- **Overarching Findings/Recommendations**

MORS

Cross-Cutting Findings (1 of 2)

- **M&S is perceived to be a key enabler to promote revolutions in**
  - Analysis
  - Acquisition
  - Education and training
- **Many of the barriers to these revolutions are cultural in nature**
  - Institutional (e.g., need to move from "stovepipes" to broader collaboration)
  - M&S (e.g., transition from Cold War models to those that reflect the New World Disorder)
  - Process (e.g., move from a few "blessed" scenarios to broad explorations of the "scenario space")

Some Needed Cultural Changes (re: GEN Welch) (1 of 2)

Area	Sub-Area	From	To
Institutional	Outcomes	Protected	Open
	Review	Bureaucratic	Subject matter expert
	Organizational	Stovepiped	Collaborative
M&S	Orientation	Model	Subject matter
	Processes	Opaque	Transparent
	Data	Limited to "validated"	Include possibilities
	Algorithms	Stable, traceable	Allow for non-linear
	Mission Orientation	Cold War	New World Disorder

Some Needed Cultural Changes (re: GEN Welch) (2 of 2)

Area	Sub-Area	From	To
Processes	Uncertainty	Suppress	Illuminate
	Scenarios	Few, "blessed"	Full range
	Analysis	Force-on-force	Military-social-economic
	Forces, concepts	Symmetrical	Asymmetrical
	Trade-offs	Limited	Full range
	Scope	Narrow (Force structure; Military worth of equipment)	Broad (Forces; equipment; doctrine; concepts; tactics; C2; ...)

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Cross-Cutting Findings (2 of 2)

- The findings of the Functional Working Groups were generally insensitive to changes in selected assumptions
- From a technology perspective, there was a broad consensus that
  - Commercial developments in communications/computing would probably not constrain M&S applications (except for security needs)
  - Significant shortfalls were projected to occur in
    - modeling methodology
    - development methodology
    - data/information understanding
    - [See next vugraph for details]

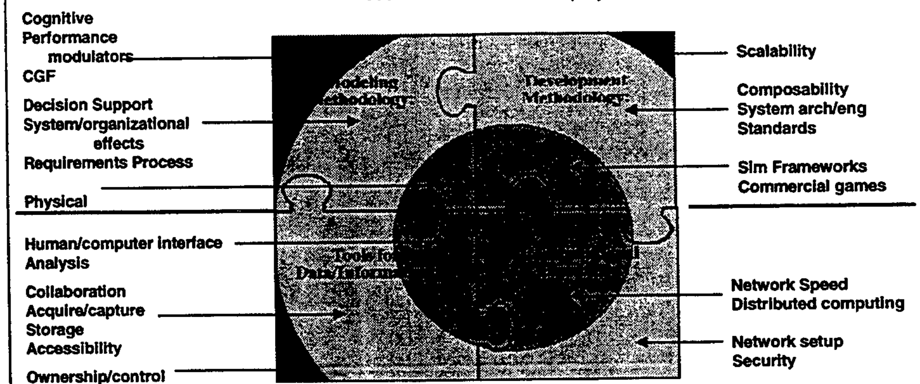
MORS

Aggregate Comparison of User Needs and Technology Projections

Needs fall below conservative projections

Needs range from Just below aggressive, to Just above conservative projections

Needs exceed aggressive projections



Cross-Cutting Recommendations

- **Institutional**
  - Develop a clear, comprehensive audit trail of existing M&S Science and Technology programs, plans
  - Create organizational focal points for
    - Simulation Based Acquisition (SBA)
    - Advanced Distributed Learning (ADL)
- **Program**
  - Develop an expanded, flexible, readily tailorable family of M&S, supporting the full range of
    - mission areas
    - functional applications
- **Research**
  - Initiate and sustain organized research programs on
    - "Soft factors"
    - Data
    - Fundamental M&S issues (e.g., multiresolution modeling)
  - Establish mechanisms to inject the results of this research into the general practice of M&S

Summary

- **These findings and recommendations should provide a sound foundation for coordinated community actions for the foreseeable future**
- **SIMTECH 2007 met the needs of the community in several dimensions; it**
  - Articulated visions of how analysis, acquisition, and education and training might be performed in 2007
  - Characterized projected conservative and aggressive bounds on M&S technology in 2007
  - Identified areas where projected M&S technology will not satisfy the needs of key functions
  - Recommended initiatives to redress shortfalls

Report of the Analysis Working Group

The report documents the deliberations of the Analysis Working Group. The group established a vision of the operational environment as it may exist in ten years, then enumerated a set of needs determined by the operational environment. The needs were coupled with trends projected by the technology group, resulting in assessments of future capabilities. The assessments and resulting recommendations are documented in this report.

The workshop was held in two parts, in December 1997 and August 1998.

Participants

Cy Staniec, Chair, Workshop I, II
Hank Dubin, Co-Chair, Workshop I
Russ Richards, Co-Chair, Workshop I
Mark Youngren, Co-Chair, Workshop II
Denis Clements, Co-Chair, Workshop II

Tom Allen	**Priscilla Glasow**	**Randall Parish**
Vernon Bettencourt, FS	**Paul Goree**	**Royce Reiss**
Jim Bexfield, FS	**Don Haskell**	**Roy Rice**
Gary Coe	**Sue Iwanski**	**Carl Russell**
Phil Collins	**Jerry Kotchka**	**Thomas Ruth**
Gerald Cooper	**Charlie Leake**	**Jeffrey Schofield**
Maj Patrick Delanye	**Joe Manzo**	**Robert Sheldon**
David Durda	**LtCol Greg McIntyre**	**John Sheppard**
Gary Engel	**Robert Meyer**	**Bob Smith**
Kevin Eveker	**Dick Modjeski**	**Brian Smith**
Dean Free	**David Noble**	**Bob Statz**
Dewey George	**Robert Orlov**	**Clayton Thomas, FS**

The working group was chaired by Dr Cyrus Staniec. Part 1 was co-chaired by Dr Hank Dubin and Dr Russ Richards. Part 2 was co-chaired by Denis Clements and Dr Mark Youngren. Special editorial help was provided by Robert Statz.

Both groups was comprised of a number of senior military analysts representing a vast number of years of analytic and simulation experience. The participants listed on this slide represent direct experience with the Army, Navy and Air Force. Skills included test and evaluation, analysis and model development, as well as a blend of experience from theater warfare analysis to low intensity conflict and operations other than war. Accordingly, the group was well suited to undertake the assigned mission.

Military Operational Environment (Analysis driver/consumer)

- **JV2010: Speed and synchronization of effects**
  - Reduced participant density per unit measure of lethality
- **Joint/coalition/intergovernmental/NGOs**
- **Information Warfare (IW) and dominance**
  - Information quality/reliability
  - Real-time information demand
  - Information overload
- **Information proliferation: International/organizational**
  - Policy influences
- **Scenario/Mission: MTW/OOTW/urban**
  - US military as support to main mission
  - Non-lethal objectives
- **Threat concerns: Asymmetric threats/RMA/WMD**
- **Resource constraints (competition with entitlements demands)**
- **Use of AWEs, ATDs, ACTDs, exercises, SBA to support decision making**

In order to forecast the simulation needs of military analysts, it is important to first consider the military operational environment that will exist ten years in the future. Although this is in itself risky, there are certain trends and intents of the Department of Defense (DoD) that improve the odds of making correct forecasts.

First, it is the clear intent of the Department of Defense (indeed, even Congress) to implement Joint Vision 2010. The implication of this decision is that analytic support must be provided to forces that will strive for information dominance and execute operations through speed and synchronization of effects. Analytic simulation must support needs related to the JV2010 pillars: precision engagement, dominant maneuver, full dimensional protection and focused logistics.

Furthermore, it seems likely that current operational trends will continue, especially if funding resources remain tight for the next several years. Whether or not there is a theater war, operational tempo will likely remain high. Joint, interagency, coalition and international agency operations will still influence military operations.

The growth of information will continue as we seek information dominance, and we will be faced with the need to preclude fatigue due to proliferation of information.

Sustaining our lead in conventional warfare, our focus will remain on asymmetric threats and operations other than war as drivers of DoD future developments.

Vision

- **Analysts supporting commanders and decision makers at all levels with timely, accurate and relevant insight and information, either directly or through powerful new analyst-developed tools, decision aids and data bases.**

As a result of the anticipated operational environment outlined on the previous slide, the vision on this slide describes the operating circumstances of the analyst in 2007. The group viewed decision making in two broad categories: operational, time-dependent, decision making and deliberate, less time sensitive decision making.

In the first case, the vision suggests analysis support "at the commander's elbow," either through responsive analysis "on the fly," or through decision tools, data displays or other aids that provide real time input to the commander's decision process.

In the second case, the vision suggests analysis using advanced methods and in more detail to provide insight into difficult decision alternatives. Issues may include "system of system" designs or supporting analysis to the Quadrennial Defense Review (QDR).

In either case, there is a flavor of faster, more timely, and better in the demand for decision information.

Analytic Environment (1 of 2)

- **Analysts will increasingly work in cooperative, distributed multidisciplinary teams to rapidly and scientifically address a broad range of problems considering many diverse factors involving high levels of uncertainty.**
- **Analysts must understand the three major players (users, modelers and analysts) and their roles.**
- **Time critical (COA Analysis) vs. non time critical (resource allocation)**
- **Analysis of the issue, not focus on the tools**
- **Different approaches will apply:**
  - M&S for Insight, Vs.
  - "Grand style" modeling
    - High Fidelity
    - V&V required
- **More customer involvement, particularly in COA analysis**

The analytic environment will be characterized by the multidimensional demands of joint, coalition and international operation. These demands will best be met by conducting analysis via teams that mix the right skills and experience to answer pertinent issues. Such teams will match analysts with a broad range of other professions, including specially trained simulators and communicators.

The competing demands of the analyst's customers and those providing technical services, like modeling, will be similar to today. The technology will permit faster and better time-critical analyses to facilitate Course of Action analyses in the field. The analyst should not let the technological cornucopia interfere with the use of good analytic approaches. The analyst must focus on the issues, not the tools.

Quick response tool technology will continue to evolve, permitting increasingly sophisticated analysis. They will be used to provide high order insights, and therefore will be less likely to require extensive V&V as large scale, high fidelity models.

There will continue to be a requirement for customer involvement, particularly in critical analyses, and the technology will facilitate such collaboration.

Analytic Environment (2 of 2)

- **Organizing for Analysis**
  - Joint/coalition
  - Intergovernmental/international/interagency
  - Distributed
  - Collaborative
  - Interdisciplinary teams to handle new concepts (e.g., flow of refugees)
    - Operator-analyst linkage
    - Modeler/Data specialist
    - Model as enabler of interdisciplinary approach (visualization)
    - Outsource (erosion of DoD internal capability)
- **New MOEs replace attrition as major discriminator between alternatives**
- **Uncertainty in model design**
  - May not know what all the critical factors are

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It is likely that there will be increased collaboration in a distributed analytic environment. Interdisciplinary teams will be required because of the need to examine concepts, such as the flow of refugees, that in the past were too large, too difficult to understand, or too far removed from the central focus of the modeling tools to be properly examined. Both the strategic focus of the military on OOTW and the availability of new tools will allow better examination of such issues.

The analyst will be challenged by this same environment to provide more focused Measures of Effectiveness (MOEs) as problems are examined that differ significantly from the traditional large scale force analyses. This issue is discussed in more detail later.

The analyst will continue to be challenged by the fact that models developed by others will be largely opaque, not because of modeling and computational technology, but because the understanding of human factors will lag the ability of machines to simulate it. Many critical human factors will not be identified, let alone understood in the next ten years.

Prioritized Needs for Procedures (1 of 2)

- **Ability to design the analysis to suit the issue**
  - Then adapt/compose the tools necessary to address the questions
  - Able to respond with either quickness or depth
  - Anticipate new scenarios, doctrine, MOE
  - Easy development of robust alternatives
- **Capability to explore:**
  - The "study space" to
    - (Scenario space, sensitivity space and multidimensional structural variables)
  - Evaluate alternatives/courses of action, to identify resource implications, robust courses of action
  - Employing
    - Parallel runs, data collection federation
    - Visualization tools
    - Principle components analysis
    - RAND multidimensional visualization tool

The first priority need for procedural improvements is in the area of analytic design. Current capabilities require a lot of time, effort and modification to existing tools and models to conduct demanding analyses. The alternative is to conduct analyses with ill-suited tools, accepting questionable fits or questionable results.

In the future, the analyst should have access to a set of tools that can be adapted or composed to suit the questions at hand. These tools may be constructive models, or other simulations coupled with advanced techniques for conducting analysis. Considering the range of possible analytic applications, this capability must be coupled with the ability to adjust resolution and run speed to needs. It must be possible to select low resolution to do quick-turn analysis for one application, or to select higher resolution for a more accurate, detailed analysis.

The second priority need is for analytic procedures that allow detailed exploration of the study space. This concept involves being able to conduct an analysis involving many decision variables (e.g., forces, systems), over a range of several scenarios, with modifications to several parameters within each scenario. Features of this capability include the ability to process runs in parallel to achieve volume, along with convenient data management and collection abilities in model federations. Advanced visualizations are also required to assist in analyzing and presenting multidimensional information. One such approach to visualization is the method developed by RAND.

Prioritized Needs for Procedures (2 of 2)

- **Analytic approaches to AWEs, ATDs, ACTDs, exercises**
- **Better capabilities to "explain" what was observed; traceability; audit trail**
- **Training/mentoring: How to do analysis in a complex environment**
- **Research: Develop analytic applications for "new science"**
  - Complexity theory, genetic algorithms, agent-based modeling
  - Data mining (intelligent data retrieval)
  - Decision support objects (post processors)
- **Joint experimentation to provide analytical constructs**

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The third priority responds to the present tendency to conduct "experiments" or "demonstrations" to support decision making or program development activities. Most of these events have some basis in simulation, are low-replication (or no replication) events, but are capable of generating large amounts of data. The challenge for the future, therefore, is to develop procedures for these events to manage data collection and to assist in the process of analyzing data that may be either complex or sparse.

The fourth priority is an improved capability to analyze what will be complex, high dimensional, large volume data effectively. This involves a combination of data analysis techniques and database management tools to facilitate handling the data. A fully developed capability will allow the analyst to detect and display cause and effect relationships and also to trace forward or backward the strings of events influencing an outcome. This capability should be useful in both a static mode, to check input data consistency, and in a dynamic mode after run execution.

The fifth priority is to provide specialized training and continuing "mentoring" to analysts in the techniques necessary to execute these more complex analyses. Implementing all of these suggestions will require analysts to understand a growing array of analytic techniques, to be conversant in simulation design and execution issues, and to be able to design and execute analyses in distributed environments.

Finally, we see a need to continue development of theory for new scientific approaches to military problems, and for testing both the doctrine and underpinning mathematical concepts. More and better experimentation will permit better modeling of the processes.

Prioritized Model Needs (1 of 5)

- **Full spectrum of tools for the range of required analysis**
  - Warfighting missions
  - Non-warfighting missions
  - Network centric warfare
  - Non-lethal: IW, C4ISR
  - Non-combatant targets (e.g., financial, educational)
  - Multi-national
  - Training Evaluation models
- **Balanced level of accuracy to allow "accuracy vs. insight" and "feasibility vs. optimization" tradeoffs**
- **Ability to highlight relationship of input uncertainty to output uncertainty**

The needs for model and simulation technology parallel the needs for analytic procedures and also address issues of expanding analytic challenges. The highest priority need is for a full spectrum of tools that allow the analyst to structure the analysis to fit the issue and then compose or select the models and tools that are appropriate for the job.

The spectrum of tools must include both warfighting models and models and tools for non-warfighting missions. JWARS is planned to fill the first requirement, so it must be maintained and developed into the future. Other recent efforts (e.g., MORS OOTWAMT Workshop, January 1997) have developed and identified needs for tools to support non-warfighting missions. Since these missions should continue to be a significant part of future operations, full development is warranted. All models and tools should be useful in multinational circumstances.

To complete the spectrum, more specialized tools are required, including robust C4ISR models, models for information warfare, models with non-lethal effects and models that address non-combat targets.

Prioritized Model Needs (2 of 5)

- **Analyst understanding of models and simulations**
  - It is important that the analyst understand what is observed
    - Analysts need a means to determine causality
  - Outputs that the analysts observe are governed by the model logic
    - Mapping between the model and the problem space needs to be explicit
    - Operative objectives and hard/soft constraints must be clearly identified
    - Especially for reconfigurable, interoperable simulations, analysts need a means to:
      - Understand strengths/weaknesses of the simulation
      - Establish model creditability

The needs for models and simulations stem from the fundamental premise that analysts need an improved ability to understand what they observe in applying modeling and simulation.

In terms of simulation technology, this translates to a need for model designs that allow cause-and-effect traceability. Moreover, the analyst should be able to easily draw relationships between the model and the problem space to be explored. At present, the design of many analytical models makes it extremely difficult to draw relations from structured variables of the model and the real world. As a result, it is also difficult to establish a strong relationship between the structure of the problem being investigated and the structure and response of the model.

In a well-structured model or simulation, the analyst must be able to trace the structure of the model from input through output and relate it to the problem space. This capability is particularly important for distributed simulations. Technological assistance is necessary to sort through and relate the various levels and structures of the distributed simulations. This notion is developed more in the next several slides.

Prioritized Model Needs (3 of 5)

- **Need good documentation for each tool, e.g., description of the concept model, logical model and data model**
  - Model logic needs to be understood in order to explain outcomes, recommendations and decisions
  - Data need to be understood
- **Need simulation/analysis tools to deal with uncertainty**
  - Less scenario dependent; broader look at scenario space
  - Broader look at cultural, political and human performance influences
  - Methods to deal with input data errors and uncertainty in output

There is a fundamental need to be able to choose tools, to structure and to execute analyses based on a thorough knowledge of the analytic issues and the structure of the tools. Modern design concepts need to be applied to the array of analytic tools in the future. A well-designed and documented "Conceptual Model of the Mission Space" (CMMS) will ensure that the real world is abstracted into a set of entities and processes that aid in understanding the associated analytic tools. The efforts associated with the JWARS and JSIMS programs provide a good foundation in this area for combat models.

Furthermore, the implemented tools require documentation of similar quality to ensure thorough understanding. A logic model of each tool, making clear the internal relationships and responses of the model, is needed to provide the analyst with the ability to explain cause-and-effect relationships. Similarly, data models need to be provided so that the proper structure and pedigree of the data are clearly available to the analyst.

Simulation technology is also required to address handling of uncertainty in analysis. Procedures are necessary to both deal with uncertainties within a single "scenario," and to deal with the uncertainty of narrowly-focused scenarios. On the one hand, processes to investigate the effects of data uncertainty will provide greater insight into the array of possible results. On the other hand, developing procedures for investigating the "scenario space," will provide greater insight into the effects of a range of situations and responses.

Prioritized Model Needs (4 of 5)

- **Multi-mode tools**
  - Model uses
    - Help develop understanding (vice requirements)
    - Capabilities
    - Optimization
    - Mixes of above
  - Operations
    - Systematic (repeatability)
    - Interactive (hardware or human in the loop)
    - Virtual
    - Mixes of above
  - Training and evaluation models

Analysts desire a set of models and tools that are designed to support many modes of analysis. Two of the more common applications are requirements analysis and capabilities assessments. In the former, the analysis seeks to find what is necessary in terms of forces or support to achieve success in the associated military operations. Capabilities assessments pose an order of battle and then seek to determine how well it performs in a given scenario. Both approaches imply detail in different areas of the supporting model.

A third analytic approach, optimization, usually requires special techniques to be used in conjunction with models and simulations. In these situations, the objective is usually to use the model to generate data on a variety of systems or parameters, then use that data as input to a mathematical programming model. The process may require generating large amounts of data on several MOEs in a large run matrix. Besides the detail necessary for various systems and parameters, there are issues of managing and analyzing large data volumes in batch mode.

The well-developed model of the future will have a thorough design to accommodate these different analytic challenges, as well as the supporting structure to manage and analyze volumes of data.

While analytic activities have generally taken place through the systematic use of closed, constructive models, analysts need the ability to orchestrate sound analyses in both interactive and virtual modes. Many issues of managing reproducibility, causal analysis and statistical procedure must be addressed for these applications.

Prioritized Model Needs (5 of 5)

- **Potpourri**
  - Model maintenance; intelligent agents for
    - Configuration management
    - Documentation
  - Dynamic multi-resolution
  - Interoperable, to include multi-aggregation/resolution
  - Highly visual, intuitive analysis environments
  - Multi-mode/dimensionality presentations
  - Means to identify/document assumptions imbedded in increasingly complex models
  - Templates for the "Red Force" in modeling SSCs

Technological solutions are also desired to time-consuming and troublesome issues in modeling and simulation. One such problem is configuration management and model documentation. Technology could solve the problems in this area by developing intelligent agents that make configuration management and documentation a simple process. The agents would make it easy to search the structure of a model, document what is found and make it easy for the analyst to trace logical flows through the model.

Technology is also required to solve the problems of dynamic and multi-resolution. Multi-resolution allows a model to operate at varying levels of detail. This capability lets the model easily adapt to different applications, ranging from course of action analysis to weapons comparisons. It can also be used as a time management tool, using detail only where that detail is required. Finally, the ability to change resolution in the course of a run would provide maximum flexibility.

In support of the more detailed, complex analysis that will be possible with advanced models, techniques are necessary to improve the analysis of outputs. Interactive, visual environments are high on the list of capabilities desired. Also necessary are techniques to support analysis involving highly dimensional data, including the ability to trace cause and effect, and to parse marginal effectiveness out among many contributing factors.

To facilitate faster model setup and better analyst understanding of the new problem domain, templates should be developed similar to those used to analyze and model Soviet forces during the Cold War.

Prioritized Data Needs (1 of 2)

- **Organizations need to be identified and charged with the responsibility to create, maintain, certify and document databases**
  - Provide data in a timely fashion
- **Need automatic scenario/database generation tools to reduce the resources (time, manpower, dollars) required to create databases**
- **Goal of database generation in person-days**
- **Need a mechanism to better incorporate lessons learned from warfare, exercises, AWEs, ACTDs, JWIDS, tests and experiments into databases**
- **Need a database help desk**
  - "Yellow pages" for data
  - Identification of who has what data
  - Identification of how to get the data

In order to gain maximum value from the needs just described, many improvements are necessary in the area of data support. The first change is to institute a comprehensive management process for data management. This includes identifying responsible organizations for data production and management. Creation, maintenance, certification and documentation are the necessary responsibilities to ensure availability of timely and accurate data.

For the analyst, productivity tools include scenario generation tools. The objective of these enhancements is to reduce the long number of weeks required to assemble the typical scenario from scratch. The tools should automate activities such as laying out order of battle, setting up force flows, arraying forces and courses of action and the like.

Another set of desired capabilities relates to the extraction and assimilation of data from "real life" — including warfare, exercises and experiments like the Army Warfighting Experiments (AWE) an Advanced Concept Technology Demonstrations (ACTD). Extraction and analysis of useful data needs enabling technologies.

In order to provide efficient access to these improved capabilities, a "help desk" is desired. Characterized as a "yellow pages" capability, it would identify who has data of what type and how to access it.

Prioritized Data Needs (2 of 2)

- **Need tools (data mining) to find and extract the data that are needed**
- **Need the ability to define "triggers" that will monitor the outcomes of a model and collect specified data when the triggers are activated (intelligent agents)**
- **Applies to any model**
- **Need ability to define the output desired (measures, data) and to collect the data needed for analysis (composable data collection)**
- **Need to make better use of tools to help understand what the data have to tell (both input and output data)?**
  - Visualization
  - Identify and analyze chaotic output.
  - Standards for metadata (source, validation,...)

Another area of data development is in data mining tools. Considering the complexity of data generated in the course of an exercise, or in complex analytic runs, it is understandably hard to extract data that is not explicitly generated. Advanced mining tools would make it possible to derive relationships across databases, or derived inferentially from data.

The next development desired is intelligent agents that assist in generating specialized data. These agents would be triggered by situations encountered in the course of a model run. Once triggered, they would act to gather detailed data relating to cause and effect, providing greater clarity and insight for the analyst.

Data processing procedures to allow the specification of desired measures, then to generate appropriate data, is a further extension of the data capabilities desired. More than just being able to generate large volumes of data or specified reports, this capability amounts to the ability to specify a data type, and a desired information level and to have the necessary data gathered for final analysis in a concise process.

Finally, a stronger ability to extract information from data is warranted. The kinds of capabilities to aid in this process include visualization tools and processes for dealing with chaotic behavior.

Panel: Analysis Technology Assessment: Development Methodology

Category	Subcategory	Assessment	Comments
Systems Architecture/Engineering		A	DoD must fund componentware
System Composability		A	DoD must fund componentware
Scalability		R	Area for research to understand feasible requirement. Not infinite due to N2 and complexity upper bounds always exist
Simulation Frameworks/Composability		A	DoD must fund componentware
Specification Language		N/A	
Standards for Design, Interoperability, and Reuse,		A	Have the data rules but not the behavior rules. Caution; standards can impose too much conformity and eliminate creative thinking.

*Legend:

Symbol	Meaning
Red (R)	Needs exceed aggressive projection
Amber (A)	Needs range from - Just below aggressive to - Just above conservative
Green (G)	Needs fall below conservative projection
None (N/A)	Not applicable

Systems architecture, composability and frameworks are interrelated and collectively rated yellow. Although it is already true that it is possible to develop a composable software system, there is no commercial market for the componentware needed by DoD M&S. It will take DoD dollars to define, implement and maintain this type of solution. DoD investments are needed now to define and prototype an efficient component-based system for M&S.

Scalability will always be limited technically. It is arguable that any software solution will have a scalability limit that cannot be addressed by computing power increases alone. While technical approaches exist to mitigate the impact of scaling up large software applications, it would be helpful for DoD to investigate whether it is possible to define a method to define the scalability of an application at requirements definition time rather than discovering scalability limitations during development.

Standards for design, interoperability and reuse are required and are emerging. It is observed that DoD can go too far in imposing standards, the result of which is the stifling of creativity. On the other hand, standards such as HLA and SEDRIS are important in the application domains to which they apply. While it is argued that DMSO is properly funded to develop the required standards for DoD M&S, there is a concern that the application of this funding may require added planning. The results of this conference may be one input to a planning review to ensure the available R&D dollars are focused in the correct areas.

Sensitivity: The priority for investment of M&S R&D funds for development methodology is lower than for modeling methodology. The sensitivity of development methodology is to the overall level of funding of M&S in general and is directly related to the overall funding level of M&S. It is likely that investment in development methodology would cease for significant reductions in M&S funding. To a large degree, funding in this area extends existing capability or adds capability in parallel with commercial technology.

Panel: Analysis Technology Assessment: Modeling Methodology

Category	Sub-Category	Assessment	Comments
Modeling Issues	Cognitive	A	Partial, limited capability only within a restricted domain even under aggressive assumptions. Red if you require a complete cognitive model.
	Performance modulators - Cognitive	R	Red since the basic cognitive models are incomplete, modeling the effect of stress, etc. on the cognitive model not possible
	Performance modulators - Physical	A	Research and data already underway. Requires resources for data collection and additional experimentation
	Physical effects	G	High resolution models only; for aggregate see next subcategory. Some specific physical effects areas Red
	Systems/Organizational effects	A	Dealing with how entities organize themselves into larger groups: information flow, networks, aggregation, etc.
Requirements Process	Analysis	A	Determining MOEs, level of resolution, etc. for the specific analysis, is and always will be an art.
	Understanding	G	Understanding main drivers and conceptual space. Efforts such as CMMS underway
	Capture	G	Functional design and knowledge engineering. Efforts underway
	Translation	A	Functional design to systems spec
Other	Model Complexity	A	Current trend toward models of increasing complexity makes it harder for analyst to comprehend. This will be exacerbated in distributed federations.
	Multidisciplinary skills/teams	A	Resources required to have people who can do the work; pay their salaries, pat to participate in collaboration, etc. New funding model may be required
	VV&A	A	Harder to do as models get bigger and more complex, particularly when distributed. Requires even more resources

***Legend:**

Symbol	Meaning
Red (R)	Needs exceed aggressive projection
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Green (G)	Needs fall below conservative projection
None (N/A)	Not applicable

Panel:Analysis Tech Assessment: Computation/Communication Capability

Category	Sub-Category	Assessment		Comments
		Conservative	Aggressive	
Computing Platform		G	G	Commercial advances will provide adequate DoD capability
Computing Power		G	G	Same as above: Moore's Law
Networks		G	G	
	Speed	G	G	Same as above: Moore's Law
	Setup	A	G	Unique DoD requirements may exceed commercial capabilities
Distributed Computing		G	G	Same as Computing platform; Moore's Law
Security/MLS		A	A	Security will remain a risk area

*Legend:

Symbol	Meaning
Red (R)	Needs exceed aggressive projection
Amber (A)	Needs range from - Just below aggressive to - Just above conservative
Green (G)	Needs fall below conservative projection
None (N/A)	Not applicable

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Panel: Analysis Technology Assessment: Data/Information Understanding

Category	Sub-Category	Assessment		Comments
		Conservative	Aggressive	
Tools for dealing with data	Acquisition	A	A	
	Storage	A	G	
	Transformation	A	A	
Presentation, Understanding, ~~Collaboration~~	HCI	A	G	
	Analysis	A	A	
	Collaboration	A	A	
Other	Ownership/Control of Analysis & Data	A	A	

*Legend:	Symbol	Meaning
	Red (R)	Needs exceed aggressive projection
	Amber (A)	Needs range from - Just below aggressive to - Just above conservative
	Green (G)	Needs fall below conservative projection
	None (N/A)	Not applicable

Sensitivity: Lack of Commercial Progress

SENSITIVITY: Commercial Technology does not advance

Category	Sub-Category	Assessment: Conservative	Assessment: Aggressive	Comments
Computing Platform		G	G	PC/workstation mix will be adequate
Computing Power		A	A	DoD M&S advancements anticipate realization of Moore's Law
Networks		N/A	N/A	
	Speed	A	A	Same as above
	Setup	A	A	Same as in Baseline
Distributed Computing		A	A	Same as Computing power
Security/MLS		A	A	Commercial advances/failures don't drive DoD capabilities

***Legend:**

Symbol	Meaning
Red (R)	Needs exceed aggressive projection
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Green (G)	Needs fall below conservative projection
None (N/A)	Not applicable

Sensitivity to Assumptions

General	If the problem domain for M&S increases, then at any fixed resource level (even if increased), either each area gets a smaller piece of the pie (more pieces), or some areas get reduced funding
Peer competitor	Technology assessment won't change but analysis vision will. This will tend to reallocate resources, making some areas worse and some better (depending upon the nature of the threat)
JV2010	Since the analyses should be able to represent a broad variety of alternative doctrines, success or failure of JV2010 should not impact this area
Defense/M&S Budget change	If the budget is increased, it will be in response to some perceived threat or outside stimulus. The particular areas most affected will be increased, others the same. If budget is cut, the JROC/force structure support will tend to be protected; we predict this
Commercial systems failure	May effect run times, limiting repeated experimentation. Otherwise limited effect
Systems trends	It is currently difficult to differentiate between small system changes. This will not change if DoD changes procurement emphasis

Recommendations (1 of 2)

- **The analyst is most important and needs preparation for the future environment**
  - DoD must increase education in analysis-related programs for uniformed and civilian analysts; increase promotion/recognition opportunities
  - Make the qualifications of the analysts a major factor in awarding contracts for outsourced analysis.
  - Provide a capstone course in military analysis techniques
  - Train study directors of complex analysis efforts involving distributed tools and interdisciplinary teams
- **Build an analytic, experimental underpinning for AWEs, ATDs, ACTDs, exercises to extract valid information and derive usable data**

Several proposals emerge to parallel the needs just identified. The first addresses education. It is evident that the advances in modeling and analytic technique just described will place unprecedented demands on the skill of military analysts. We advocate a formal educational course that trains analysts in the techniques and processes involved in complex analysis.

Since the capabilities will continue to emerge and be refined, a continuing education process is also warranted to keep analysts qualified in the latest techniques.

In order to continue the advancement in analysis, we also advocate a program of continued research. The research should address both military phenomenology and scientific advancement. Military phenomenology studies are especially important in the context of future warfighting approaches. Many of the scientific disciplines of interest have already been suggested in the previous discussions.

A particularly important suggestion is to underpin AWEs and ACTDs with an analytic process that allows valid conclusions and usable data to be extracted from the process. This includes both a solid experimental structure for the experiments as well as analytic procedures to extract valid insights from the volumes of data generated.

To support some of the capabilities already described, intelligent agent technology should be pursued.

Recommendations (2 of 2)

- **Support a program of research/experimentation for**
  - Tomorrow's military mission phenomenology
  - Application of emergent science into analysis
- **Basic research in the modeling of combat needs to be performed if the models of the future can respond to current and projected requirements**
  - Cognitive processes (C2)
  - "Soft" factors
  - Aggregation and disaggregation
  - Explicit treatment of uncertainty
  - Others...
- **Data need as much attention and money as model development (e.g., JWARS, JSIMS)**
  - New data needs - C4ISR, distributional information, etc.
  - Current data needs - releasable information from Services
  - Faster, automated data collection and validation

Summary/Observations

- **Demands for decision making information will continue to grow**
  - Complexity and diversity of the issues will also increase
  - Information will increasingly be drawn "all source/any source"
  - The success of "analysis" in the future will depend on the ability to prepare for and operate in that environment

In the year 2007, we believe the decision making environment will remain difficult due to the complexity of operational missions and the nature of defense decisions to be made. Issues will tend to be difficult, involving systems of systems or components of systems operating in uncertain environments and circumstances. We will find that data are available from many sources in the future, and we must be prepared to exploit it. By generating the kind of simulation and analysis capability described in this report, technologists will help analysts take a large step forward in the ability to conduct analysis. However, to be a successful application in the decision making environment of the future, there will be a need for the ability to gather and use disparate data and apply the models we have described through this workshop.

Report of the Acquisition Working Group

Participants

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We agreed with the December definition of acquisition for the purposes of the workshop. It is more than that tiny sliver that lies between requirements definition and everything else that goes on in the life-cycle of a military product. We have chosen to define acquisition, for this exercise, as not being separate and distinct from operation, sustainment, etc. It should be thought of as total life-cycle.

Acquisition Working Group Objective

- Characterize the acquisition process of 2007
- Identify major changes that must occur to execute the acquisition process
- Identify shortfalls in M&S
- Prepare actionable recommendations to address shortfalls in investments and incentives, policy and organization

Identify and define needs and issues of the acquisition community of 2007 toward meeting JV2010 and other DoD goals.

The SIMTECH II group re-evaluated and revised the vision, characterization of M&S in SBA and the changes that need to occur to realize the vision.

The changes were categorized into cultural, management, policy and technical.

Acquisition Vision and Goals

An acquisition process in which DoD and industry are enabled by robust, collaborative use of simulation technology that is integrated across life-cycle phases, functions, and programs to:

- **Substantially reduce the time, resources and risk associated with the entire life-cycle process;**
- **Increase the quality, military worth and supportability of fielded systems while reducing total ownership costs throughout the life-cycle.**

Our vision and goals therefore are defined here. The distinction that acquisition is total life-cycle support and not the traditional early phase support and throw it over the fence. DoD and Industry are enabled in a collaborative environment enabled by simulation technology. This environment is robust in its breadth and depth of domain.

The vision encompasses the collaboration between acquisition phases and functions within a program and the collaboration between programs.

Functions refer to acquisition processes that occur throughout the acquisition process such as test and evaluation, training, combat development and engineering and manufacturing development.

Such an environment must address time (schedule), resources (people and funding) and risk across the entire life-cycle.

We cannot sacrifice the quality (performance and support) of the products we are developing for the sake of costs. But we must control the total cost of ownership.

When the vision is implemented it will be a giant upon which the program managers can stand to execute their programs.

Characterizations of the End State

- **Increased contractor total system responsibility with more efficient government insight**
  - Government-industry trusted partnerships
  - Shared data and models
- **Highly integrated electronic work environment — across all life-cycle functions**
  - Concurrent development with continuous evaluation of alternatives
    - Ready accommodation of technology insertion/turnover
    - Flexibility to accommodate a major force restructuring
    - Integrated training/analysis development
- **Reduced life-cycle costs and development time to be consistent with commercial practices**
- **DoD commitment to making the most informed acquisition selection/decisions based upon:**
  - Life-cycle cost
  - Authoritative data and model sources
  - Collaborative model and simulation use
  - Proper IPT use — resourced, funded and empowered

MORS

Above are some of the characteristics that we envision for the SBA end state.

As time goes on, there will be more and more of the development responsibility shifting to industry. Partnerships that permit the sharing of data and models must be developed that have trust as a cornerstone of the relationship.

The environment will be an electronic, one highly integrated across all life-cycle functions. This integrated digital environment will permit the early and continuous visibility and evaluation of system development alternatives. Such alternatives can include technology insertion and turnover, major restructuring of forces integrated with training.

Typical military production times can be as much as 10-15 years. Commercial practices allow for much shorter times. The DoD must become more consistent with some of these commercial practices. The difficulty in doing this is that the DoD does not build large quantities for profit and does not invoke the incentives of industry.

There must be a commitment by DoD that life-cycle cost is the basis for making acquisition selection decisions. The development and distribution of models that are authoritative needs to occur. We must begin migration toward making the most informed acquisition decisions we can. We believe that M&S enables this. IPT must be taken seriously — properly resourced, funded and empowered.

IPTs need to be trained, intelligent IPTs must be formed that really know how to function.

Major Changes That Must Occur To Achieve That Vision (1 of 4)

- **Cultural**
  - Greater reliance on M&S
  - Horizontal integration and break down stovepipes
  - Government/industry trusted partnerships
  - Pervasive sharing of models and data
  - Up front investment in modern processes
  - Enabling of international involvement
  - Ability to conduct comprehensive life-cycle trades
  - Flexibility to accommodate a major force restructuring
  - Education for the vision

MORS

There are four aspects to the major changes that we see must occur: Culture, management, policy and technology/environment.The second workshop agreed with the December workshop on the cultural changes.

We must begin to move to greater reliance on M&S to reduce costs. There must be integration across services and domains. We must find a way to foster trusted government industry partnership to promote pervasive sharing of models and data. This will not come by dictate but will necessitate an incentive for sharing.

The concepts we are promoting are complex and difficult to comprehend. A program to educate future executives, program mangers, etc. must be initiated that educates for the vision.

Incentive for sharing, must work on incentives; an example is the Internet.

Major Changes That Must Occur To Achieve That Vision (2 of 4)

- **Management**
  - Alignment of development time to be more consistent with commercial life-cycle times
  - Ready accommodation of technology insertion/turnover
  - Business Process Reengineering (BPR) of data production
  - Functional IPTs are a way of life
    - Leverage M&S across functions/domains-avoid redundancy
  - Authoritative sources for models and data
    - Program manager provide for system models
    - Other stakeholders for environment, etc
  - DoD commitment to life-cycle costs basis for acquisition selection/decisions

The incorporation of the paradigm of SBA is being pursued in commercial practice at a faster pace than DoD. These techniques are providing for faster cycle times and reductions in production costs. The DoD must be responsive to these changes and accommodate industry.

This paradigm will allow for major system modifications and consideration of significant alternatives at various stages of product development. Management must be responsive to the opportunities provided.

Major Changes That Must Occur To Achieve That Vision (3 of 4)

- **Policy**
  - Up front M&S investment as the norm to reduce life-cycle costs
  - M&S strategy integral to the total acquisition plan
  - Models and simulation critical to formal acquisition decisions
    - Policy guidance on what the DAB can expect and guidance to the PM on what should be provided
  - Incentives for all stake holders to participate
  - DoD policies and guidance for M&S use
  - Policy and guidance on sharing M&S
    - Between government and industry
    - Across programs

The roles and responsibilities of government and industry must be defined and redefined as the barriers and stovepipes in the traditional life-cycle functions begin to blur into continuous integrated functions.

A policy must be established that provides up front investment in the capabilities to take full advantage of SBA. A negative incentive is established if the funding for these efforts are taken from the Program Managers (PM). There must be a mechanism for providing incentive for the PMs who use these methods properly for saving life-cycle costs. This includes the aspect of project funding distribution which will change in an integrated environment.

We must identify and change the policies and guidance that are inhibitors to making SBA successful.

How do we institutionalize M&S to be a critical part of formal acquisition decisions?

Major Changes That Must Occur To Achieve That Vision (4 of 4)

- **Technology/environment**
  - DoD-wide knowledge-based infrastructure to enable SBA
    - Program-specific functional integration
    - Appropriate utilization of COTS and GOTS
    - Interoperability and reuse standards
  - Ability to comprehend and conduct trades across highly diverse mission/functional areas
  - Ease of use
    - Cross platform/plug and play/"throw away"
    - Rapid initialization and intuitive data interpretation
  - Validated data sources, models and tools
  - Investment in a comprehensive modeling capability

MORS

Data in the form of knowledge must be sharable across DoD, in and across programs. At the heart of the SBA capability is a source of knowledge. There are several technologies that will enable this: Object Oriented (OO) Data and Browsers. These will permit a common form of the data (OO), a common means of distribution (the Internet/Intranet) and a common means of access (browsers).

The focus needs to be on reuse and interoperability standards to allow this to happen.

DoD is not the leader in many of the information technologies and consequently we can not dictate the form of developments in this area. We must take advantage of what Industry is doing, leverage their efforts and apply the solutions to our problem areas.

The DoD must prepare itself for very complex systems-of-systems analysis. These analyses will require the advanced technologies offered by the SBA paradigm.

The implementation of these technologies are going to require large amounts of information being transmitted to a large number of distributed sights requiring high performance high band width communications, but probably only a fraction of the time.

What Shortfalls Exist in Functional Requirements

- **Investments and incentives**
  - Inadequate up front investment
  - Lack of personal and programmatic reward for implementing the vision
  - Insufficient sharing of M&S and data
  - Not enough effective government and industry partnerships
- **Policy initiatives**
  - Lack of guidance for M&S use in formal acquisition decisions
  - Lack of early and continuous program focus on M&S in acquisition life-cycle
  - Current policy limitations on effective use of commercial domestic and international products and services
  - No common implementation for sharing M&S and data
- **Organization and focus**
  - No mechanism to ensure compatible processes and approaches
  - Lack of adequate stewardship for M&S tools, standards and data
  - Lack of stewardship for M&S education and training
  - Absence of intellectual foundation for SBA implementation
- **Technical challenges**
  - Data availability, quality, credibility and vetting process
  - Interoperability of tools
  - Sensitivity/security of M&S and data
  - Physics-based, cost, performance and scheduling models
  - Interoperable, variable-resolution family of models
  - Limitations in hardware and software capabilities

The shortfalls as we related them to Acquisition:

- We don't have an effective way to model what we need.
- Distributed operations are increasing. We will focus on integrated IPT models to evaluate the trades between design and everything else (manufacturability, testability.)
- We need models that are easy to use
- Models that demonstrate military worth

Inadequate investment means inadequate corporate investment, i.e. across programs and services. Now a program will do what's right for it, but there is not the investment to take the best products or lessons learned across other programs. There has to be investment in the technology, not by individual programs, but rather by concerted programs. Compatible means more than just common processes.

The other challenge on which we agreed with Workshop I is the lack of an organizational focus to resolve the stewardship and direct compatible processes and approaches. This management could also include an executive training team for SBA.

Actionable Recommendations to Remedy High Priority Shortfalls (1 of 2)

- **Investment and incentives**
  - Establish and support sufficient M&S-infrastructure investments in the POM
  - Provide incentives to all stakeholders accompanied by adequate up front investment for M&S use early and throughout the life-cycle to:
    - Minimize total cost of ownership.
    - Shorten acquisition cycle time
    - Improve support to the warfighters and decision makers
  - Incentivize active partnering between
    - Acquisition programs
    - Government and industry
- **Policy initiatives**
  - Establish policy/guidance to address M&S use in formal acquisition decisions
  - Direct Requirements developers and SAEs be held accountable to:
    - Maximize SBA benefits
    - Reduce life-cycle costs
  - Define a policy to utilize emerging products and services both commercial domestic and international to maximize SBA potential
  - Establish DoD policy and a common implementation for sharing M&S and data
- **Organization and focus**
  - Identify and empower an organization to enable:
    - Dedicated enduring pilot and flagship programs
    - Stewardship for managing SBA
  - Focus by priority what needs to be done

Org and Focus: It is beginning to become very widely accepted that there is enormous potential to reduce total life-cycle costs and maintain system performance through the proper construction, distribution, access and use of system-of-systems knowledge.

SBA partnering needs to be done on many levels:

- Top level through M&S Executive agents working with Industry conglomerates.
- PEOs working with domain specific industry.
- PMs working with prime contractors.

Dr Gansler's letter to the services on SBA underscores his commitment to this effort but doesn't put a hook in place to insure that this is done.

We agreed that there needs to be a single point to manage SBA, not a council or a policy organization but someone empowered to make the needed decisions with the horsepower to back them up.

Actionable Recommendations to Remedy High Priority Shortfalls (2 of 2)

- **Technologies**

  Modeling methodologies are the most serious shortfalls that require high priority for funding

Issue	Do What
Representation	DMSO identify as a high priority in the next version of the DoD M&S Master Plan
Simulation Techniques	Community working on CGF should reprioritize and put the effort into new techniques
Levels of Abstraction	DoD needs to consider link between CAD/CAM and operational effectiveness

Sensitivity Analysis (1 of 3)

- **Mission trends**
  - A peer competitor emerges prior to 2007 [minor]
    more likely to affect what we buy, not how
- **Strategy/operational trends [minor]**
  - Joint Vision 2010
    - Perceived as successful (i.e., new joint concepts of operation are adopted)
    - Perceived as unsuccessful (i.e., return to more deliberate/mass oriented operations)

Sensitivity Analysis (2 of 3)

- **Institutional trends**
  - "Top-line" defense budget: +/-20% from the baseline
  - [Moderate/Major] If there is a top-line 20% reduction, this would have a favorable impact because it would force people to use SBA
  - M&S expenditures: +/-20% from the baseline [Moderate/Major] A reduction would adversely impact SBA
- **Systems trends**
  - Limited acquisition resources prompts DoD to plan to retain systems for 50% longer than existing systems [Moderate +] For systems retained longer, there will be opportunities for ROI using SBA in the O&S tail
  - DoD shifts to an acquisition strategy that emphasizes more, cheaper (possibly lower tech) systems [Moderate +]
  - SBA would allow for analysis of more complex system
  - of systems

Sensitivity Analysis (3 of 3)

- **Commercial trends**
  - Reliance on commercial products proves to be a failure (e.g., commercial products fail to provide adequate environmental robustness or respond adequately to DoD's unique needs), prompting DoD to rely less on commercial products, services [Moderate +]. SBA will be helped - it will aid in being more selective in the response
  - Acquisition reform/RBA fails to deliver (e.g., acquisition reform proves disappointing) [Major -]
  - This will have the effect of cutting off support for SBA

Report of the
Education and Training Working Group

Participants

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Executive Summary (1 of 2)

The past decade has seen Modeling and Simulation (M&S) in support of education and training move from concept to reality. Ten years ago, almost to the day, the concept of distributed simulation in support of training was being developed at the Warrior Preparation Center. Since that time, this revolutionary concept has been proven and has grown to be commonplace. During the same time period, the foundations for distributed education were formed with numerous courses being given at every education level.

The benefits that M&S and its associated technologies bring to education and training are no longer in doubt. The initial technology base of inexpensive high bandwidth communications, software engineering, high performance computing and multi-media presentation tools coupled with the explosive growth of the Internet is in place and improving daily.

The next ten years will no doubt see equally significant changes. It is the purpose of this panel on education and training to attempt to define the operational requirements for military education and training for the next decade. The follow-on workshop will attempt to define the M&S capabilities required to meet these requirements

The primary focus of this workshop has been constrained to focus largely on training and education in support of developing skills for the military and civilian warfighting force. Little discussion took place over the equally important problems associated with educating and training personnel responsible for either the acquisition of these forces or the policy side of DoD operations due to the time constraints. It is clear that these other areas deserve equal attention and that the ultimate solutions are interconnected and synergistic.

The world has changed from a bi-polar threat environment, focused on high intensity large force combat, to a non-polar environment in which the military is employed across a range of operations from humanitarian operations to counter-terrorism to combat against potential threats in virtually any region of the world. As a result, the doctrine employed by the military is in the process of the most significant changes in the last 50 years. All of the services have programs (the Army After Next, the Alternative Air Forces, etc) that are in the process of defining the organizations, weapons systems and doctrine that will keep them as dominant in the next 20 years as they were in Desert Storm despite significant drawdown, increased PERSTEMPO and OPTEMPO and increased breadth of operations. Given this change, education and training will play a more significant role than ever before.

Multiple technologies are likely to emerge that will be critical for training applications. An exhaustive list is not provided here, but some of the key technical areas area. Improvements in communications and computer processing should enable long-distance learning/training applications such as ADL. Web-based technologies such as Java should help to provide ease of application sharing across platforms that will lead to improvements in DL and ADS. Advances in AI will hopefully lead to improvements in human behavioral representation — a key to improving interactive training with simulations.

It is critical that we begin to exploit these new technologies as soon as possible. The rapid evolution of technology will tend to make detailed, long-to-develop plans obsolete before they can be implemented. Instead, we should begin to focus on how we can utilize emerging technologies and gain experience in applying them that can be built upon.

Executive Summary (2 of 2)

The current training and education process cannot maintain pace with the rapid change in technology. Technology changes demands a rapid, flexible process that can educate the warfighter quickly and satisfy a variety of technical capabilities. A complete revision to the training process must take place that can accommodate these changing needs.

The influx of new technologies for training will also require new methods of training in applying them. We must adopt methods that will help us change the WAY we learn in addition to WHAT we learn. New learning methods that stress the ability to assimilate information will likely be required, instead of traditional methods that focused on memorization or repetition.

Training and education within the services and across DoD is believed to suffer from a lack of coordination. While efforts exist that are taking advantage of new technologies to improve training and education, these efforts may not be widely known or synchronized. It is recommended that a periodic "needs assessment" be performed which would (1) identify shortfalls in the training and education domains; (2) prioritize these needs and fund efforts to correct them via an implementation plan; and, (3) develop a feedback process that will periodically revise this implementation plan.

Currently, the responsibility for education falls primarily on the service institutions. However, with the trend in downsizing across the DoD it is expected that institutions will have fewer resources upon which to draw to implement education and training. Individuals must take more of the responsibility for training and educating themselves. DoD must adopt a policy that will provide incentives for individuals to improve themselves through education and training. Likewise, institutions must share in this process so that available resources are not squandered.

Changes in the personnel management system must be made. Current practices involve training individuals early in their careers with the requisite knowledge that they will need. However, the rapid evolution of technology often makes knowledge obsolete within only a few years. Therefore, the personnel systems must accommodate the need for continuous training throughout the career cycle. The system must make allowances for continuous training and education throughout one's career — not just "frontloaded" at the beginning.

To facilitate this, broadbased training must be integrated with specific, tailored training throughout a soldier's career. An example of broadbased training might be knowledge of basic computer operations that could be used to gain knowledge when necessary. This would allow the user to access more specific information as necessary. Links to non-military (i.e., universities, community colleges, etc.) will be necessary to expand the knowledge base for such information.

In summary, this workshop established operational requirements that help to define the technologies to be addressed in the next workshop. In addition to the requirements for changes to be made in training and education systems, numerous policy changes must be made to implement processes that make effective the technology changes. The bottom line is that the last decade laid the foundations for the necessary technologies to "revolutionize" education and training; however, the foundations for the necessary policy changes still need to be put in place.

Why Are We Here?

Workgroup Objective

"After consideration of the lessons learned from the retrospective assessment, the participants will identify and prioritize the needs of the users of military M&S"

"If we continue to develop our technology without wisdom or prudence, our servant may prove to be our executioner."

- General Omar Bradley

MORS

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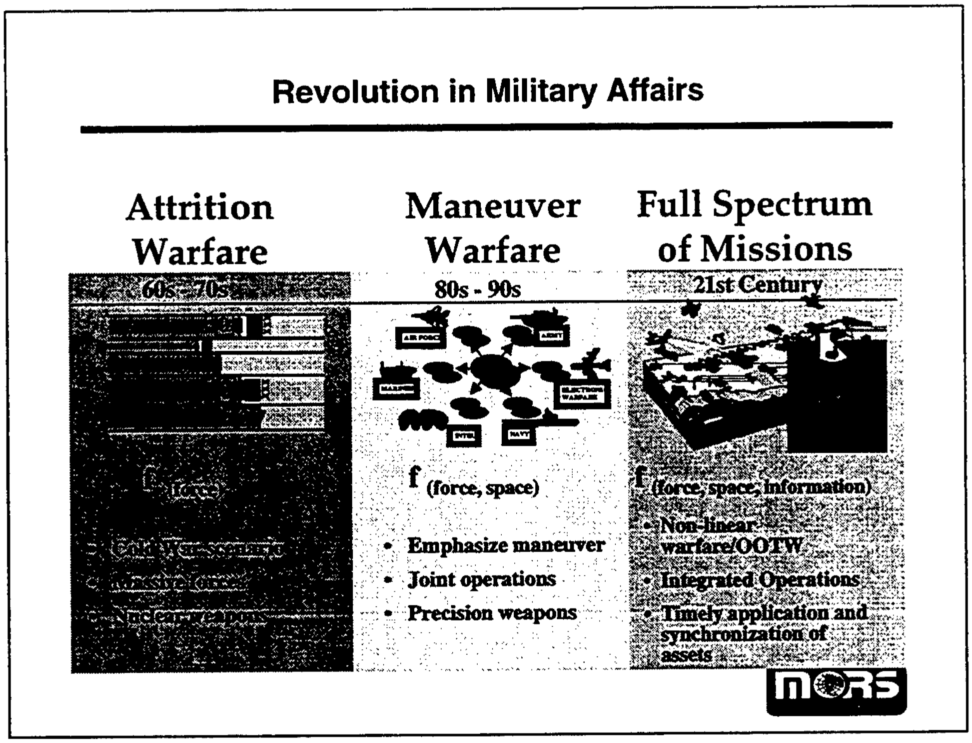
The next ten years will no doubt see equally significant changes. It is the purpose of this panel on education and training to attempt to define the operational requirements for military education and training for the next decade. The follow-on workshop will attempt to define the M&S capabilities required to meet these requirements.

The primary focus of this workshop has been constrained to focus largely on training and education in support of developing skills for the military and civilian warfighting force. Little discussion took place over the equally important problems associated with educating and training personnel responsible for either the acquisition of these forces or the policy side of DoD operations due to time constraints. It is clear that these other areas deserve equal attention and that the ultimate solutions are interconnected and synergistic.



The Background:

The world has changed from a bi-polar threat environment, focused on high intensity large force combat, to a non-polar environment in which the military is employed across a range of operations from humanitarian operations to counter-terrorism to combat against potential threats in virtually any region of the world. As a result, the doctrine employed by the military is in the process of the most significant changes in the last 50 years. All of the services have programs (the Army After Next, the Alternative Air Forces, etc) that are in the process of defining the organizations, weapons systems and doctrine that will keep them as dominant in the next 20 years as they were in Desert Storm despite significant drawdown, increased PERSTEMPO and OPTEMPO and increased breadth of operations.

Given this change, education and training will play a more significant role than ever before.

Trends Affecting Training (1 of 2)

- **More complex military requirements**
  - Expanded mission space (US and foreign)
    - More diverse threats
    - Expanded emphasis on non-combat operations
    - Expanded operations with non-DoD and non-governmental
      - Coalition and combined operations
    - Increased operations and decision space with reduced decision time
  - More complex equipment
  - Increased OPTEMPO
  - Continued force downsizing
- **Casualties and collateral damage unacceptable**

The military faces a significantly expanded mission space: threats ranging from drug dealers to terrorists to major regional powers. By the end of the next decade, it is likely that major powers such as China will arise that are capable of posing serious threats to the US. In addition to combat operations, the military is expected to provide non-combat support around the world in combination with both non-DoD and non-government organizations.

With the increased mission space, comes increased operations space as a result of weapons systems that can engage multiple targets at extended ranges, of weapons systems that can travel and fight at significantly increased speeds, and C4ISR systems that can provide huge volumes of high resolution information about both the military and cultural environment. Coupled with this increased operations space, comes increased decision space with reduced decision time. More options to explore, high OPTEMPO conflict, broader threat spectrum all result in less time to make decisions.

Making the problem even more complex is the political impact of casualties or collateral damage on the employment of military forces. Numerous examples of political impact range from Somalia to Desert Storm.

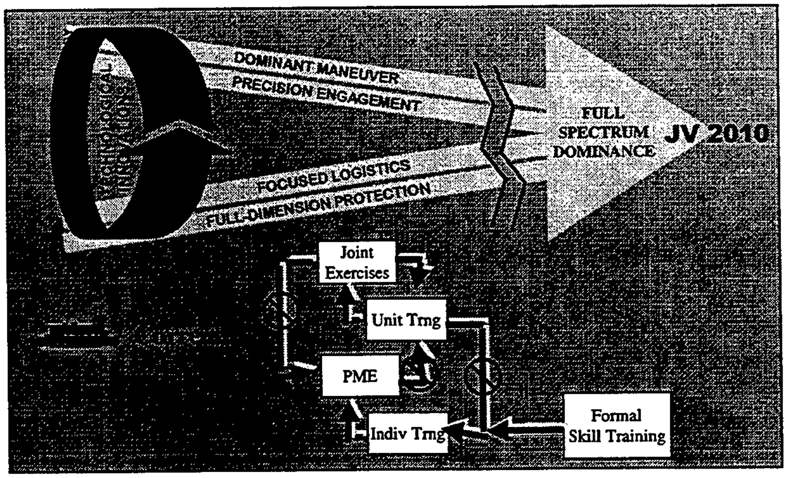
Trends Affecting Training (2 of 2)

- **Tailored military organizations**
  - Force composition and C2 change with military requirements
  - More complex organizations
    - Increased reachback operations
    - Common operational picture
    - HCI/Human-human interface — increased requirement for collaboration
- **Merging of training, planning and military operations**
  - Merging of M&S and C2 systems
  - Embedded analyses in training events
  - Use of instrumented training events to provide data to support other domains
- **Outsourcing**

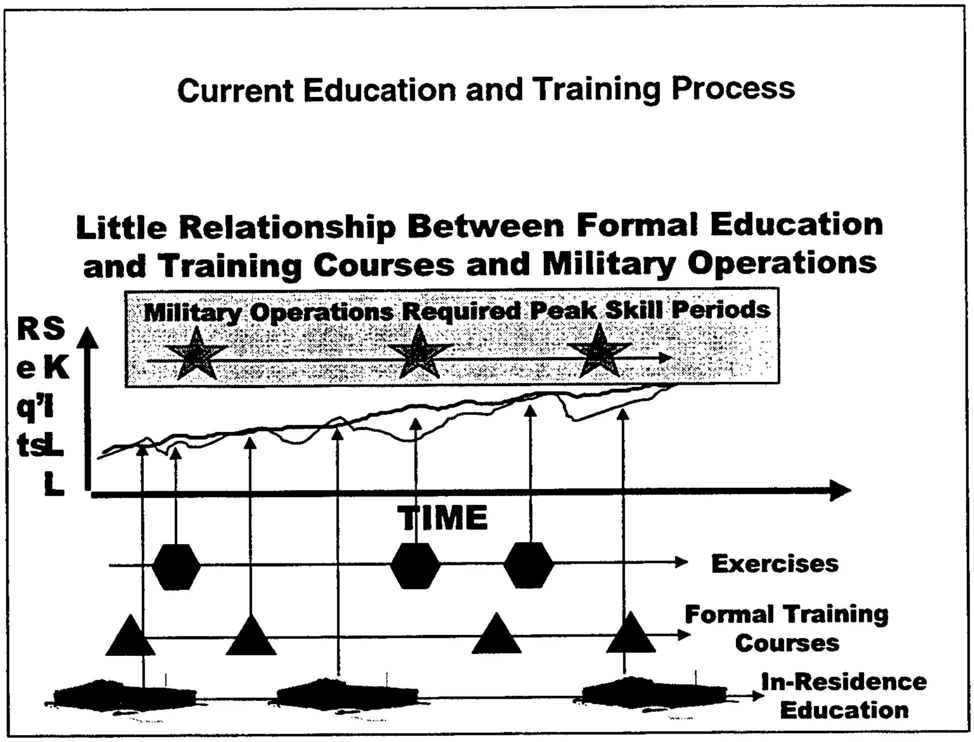
In support of the expanded mission, operations and decision space and the significantly smaller force, the structure of the forces deployed has changed significantly. Smaller forces, increasingly joint, tailored to specific missions with significant support remaining in the CONUS or theater rear areas are becoming the norm. The result is a force that depends on precision and mobility to achieve "overwhelming force" with minimum casualties and collateral damage.

The result of these factors is a significant increase in the requirement for a more highly educated and trained force that can be successful with fewer forces across a broader range of operations in a highly visible battlefield.

Current Education and Training Capabilities



The current process has a number of elements: In-residence/correspondence/seminar PME; hands-on, informal apprenticeship; and military exercises. The consequence of stove-piped education and training is a significant limitation in our ability to merge the pillars of JV 2010 and execute the vision of "Full Spectrum Dominance." In other words, if we don't "revolutionize" our education and training processes we won't be able to "revolutionize" our military capabilities.



In general, while each element imparts critical knowledge in and of itself; they are independent and not linked together thus unable to provide the degree of either growth or sustainment that a well structured-well integrated program might bring.

In addition, and perhaps more critical, the periods of peak performance only coincidentally match military requirements because the training and education events are fixed events pushed to the military member rather than a resource able to be pulled when required.

Future Education and Training Requirements (1 of 2)

- **Valid training metrics and methodology**
  - Define training requirements and performance standards
  - Training effectiveness measures
  - Using results to refine and improve the process (diagnose, fix and improve)
- **More efficient knowledge and skill transfer**
  - Limited training time and resources available
  - More information transfer required
  - Accurate determination of current level of knowledge
  - Training tailored to individual's and team's most efficient learning method

Given the smaller forces (downsizing); the increased OPTEMPO/PERSTEMPO; and the increasingly complex world around us, the education and training process must be significantly more efficient — it must transfer much more knowledge in much less time.

Additionally, the education and training process must be a life long process because of the rapidly changing world and the need for each person to be proficient in more skills (fewer people — more complex work).

Lastly, the training/education must come to the people not the people to it (increased OPTEMPO/PERSTEMPO). Two technologies are in their infancy which if developed and integrated under the Advanced Distributed Learning (ADL) initiative, hold much promise to meet these demands: ADS (growing out of distributed wargaming capabilities like the Joint Training Confederation and STOW) and Distance Learning (DL) coupled with the rapidly growing commercial entertainment market.

Future Education and Training Requirements (2 of 2)

- **Lifelong training**
  - Greater breadth of required skills
  - More frequent skill changes required
  - Must train with non-DoD agencies
- **Continuous training opportunity**
  - Distance learning
  - Advanced distributed simulation

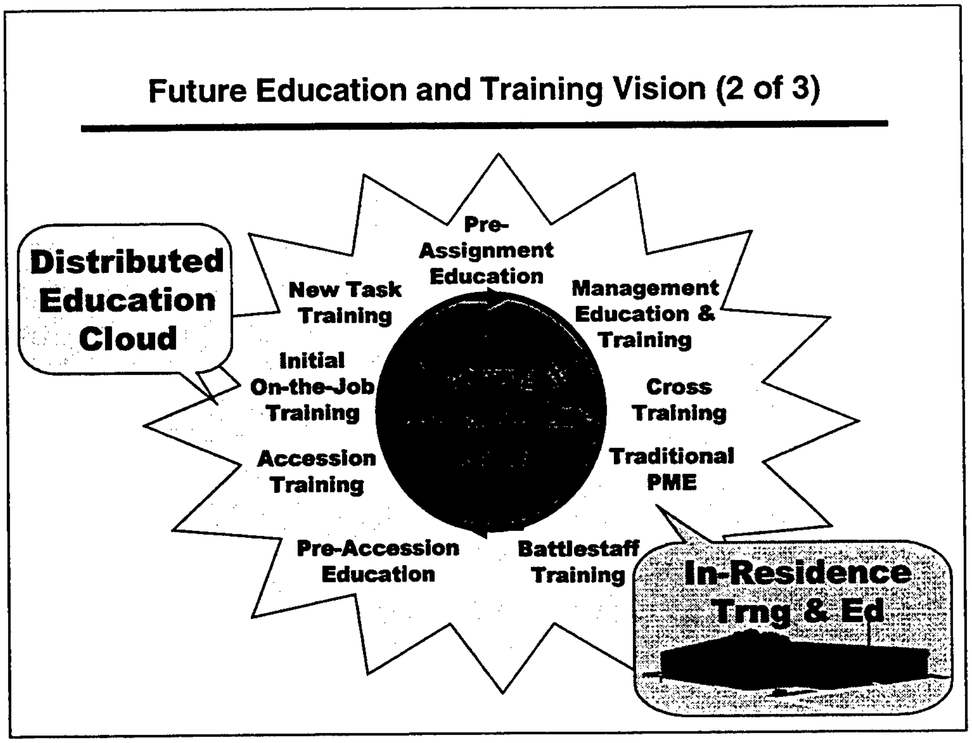
Future Education and Training Vision (1 of 3)

- **Just-in-time/just-enough training tailored to requirements and delivered when and where required**
  - Education and training mutually supportive
  - Education & training research expanded
  - Leveraging Non-DoD technology advances
    - Non-DoD assets
    - Stimulate commercial market place
- **Teaching "how to learn" will become as important as training "how to do"**
- **Use of simulation for discovery learning**
- **Training, analysis and acquisition communities will provide mutual support and exploit common resources**

The vision of just-in-time/just-enough training distributed when and where required is self-explanatory.

It's important to realize that this capability represents a major paradigm shift in how we currently train and educate with DoD. This shift increases the responsibility for learning from the institution to the individual and requires a significant focus on teaching "how to learn" and thus an increased focus on the science of education. As the individual becomes responsible for learning, the institutions become responsible for creating a learning environment and providing both infrastructure and content.

The result could look something like the next slide.



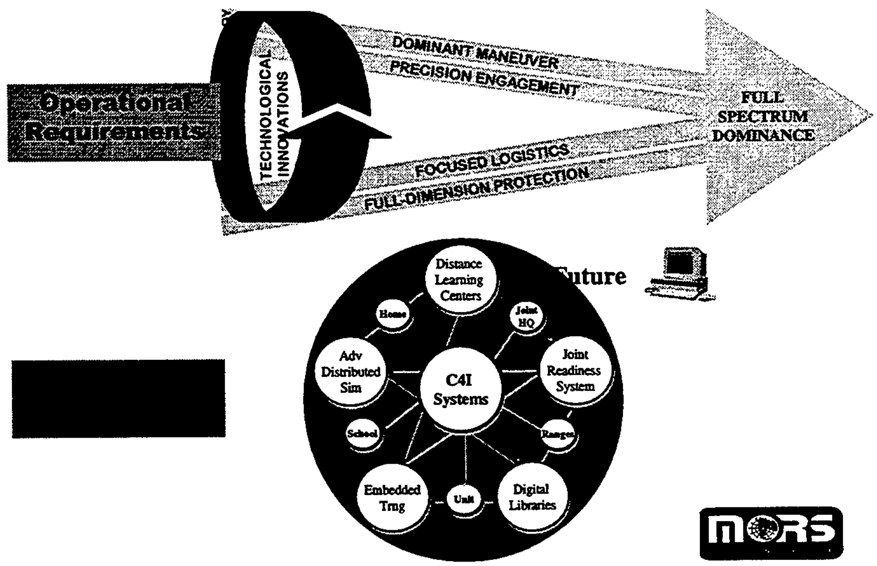
An Education and Training Cloud:

The individual can draw upon a distributed education/training cloud fed by the institutions and available to the 'lifelong student' when and where he requires it. (A pull system support just-in-time/just-enough training.)

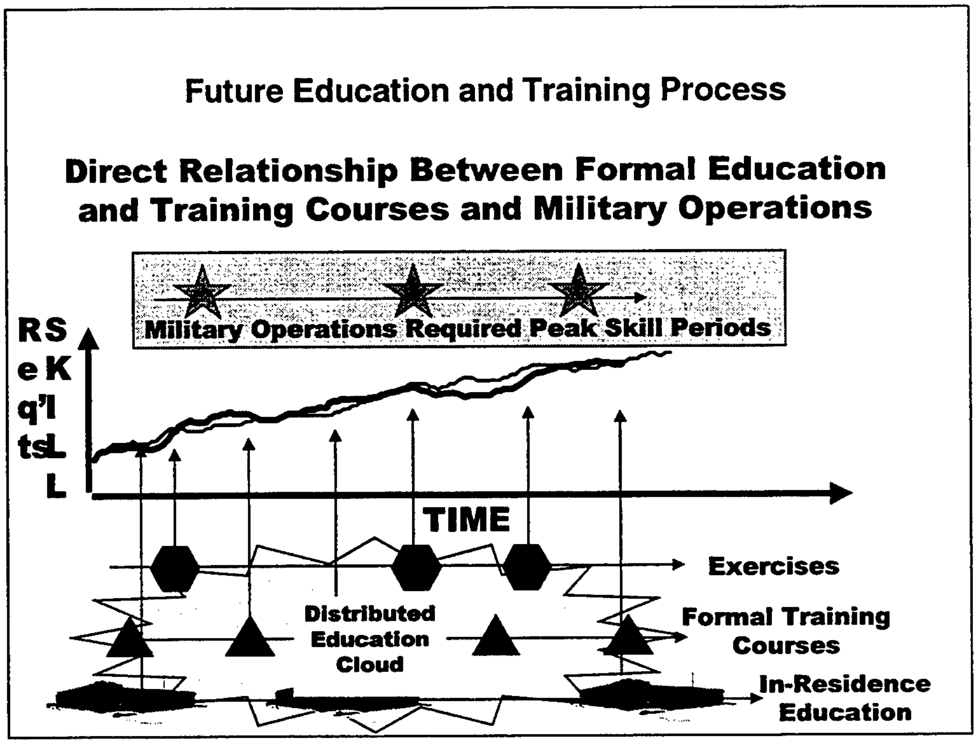
The in-residence programs will still be vital, but will shift focus to teaching "learning processes" and group skills and provide the "glue" that feeds knowledge across elements.

Producing this change in the current stovepiped education and training process will produce the following outcome:

Future Education and Training Vision (3 of 3)



A fully integrated, constantly available education and training system that supports "pull" as well as "push" — fully supporting meeting the goals of JV 2010.



A continuous growth in capabilities with new skills acquired based on military needs: new jobs (assignments) or military events requiring new skills.

The goal is to transition today's classroom focused education process and unstructured hands-on training into a continuously available distributed system composed of courses and on-line knowledge bases that can be pulled by the "life long student" as required, giving each individual the resources to become an "expert" when he or she needs to be.

Observations

- "Without data we are nothing" LaBerge '87
- Past 10 years built technology building blocks — we must develop a system that will exploit current and future technology
- Education and training science requires extension and exploitation
- Rate of growth in technology outpaces ability to exploit it — institutional change required to take maximum advantage of emerging technologies
- Full exploitation of the available opportunities requires significant cultural change within DoD. (Most critical issue)
- Exploitation lags new technology despite ever increasing requirements
- Total force training must be consistent

MORS

The key observations from the workshop focused around the fact that it is not technology that is holding back the education and training revolution. It is: 1) a lack of a digital knowledge base (data); 2) inadequate linkage between educational science (how we learn and how to train); 3) the lack of linkage between military educational institutions and the training systems; and, 4) the lack of clear personal responsibility for education and training and a supporting system to make it possible.

To put in place a "revolutionized" education and training system requires significant institutional change accomplished through major policy changes.

Policy Requirements (1 of 2)

- **Establish comprehensive educational process synchronized across DoD**
  - Perform "needs assessment"
  - Develop education action plan for DoD education and training
  - Develop a comprehensive training methodology
  - Develop comprehensive feedback process
- **Responsibility for education and training shared between institutions and individuals**
  - Adopt policy to "incentivize" individuals
  - Adopt policy to "incentivize" institutions
- **Develop T&E experimentation plan within the scope of the JV 2010 experimentation campaign plan**

Training and education within the services and across DoD is believed to suffer from a lack of coordination. While efforts exist that are taking advantage of new technologies to improve training and education, these efforts may not be widely known or synchronized. It is recommended that a periodic "needs assessment" be performed which would (1) identify shortfalls in the training and education domains; (2) prioritize these needs and fund efforts to correct them via an implementation plan; and, (3) develop a feedback process that will periodically revise this implementation plan.

Currently, the responsibility for education falls primarily on the service institutions. However, with the trend in downsizing across the DoD it is expected that institutions will have fewer resources upon which to draw to implement education and training. Individuals must take more of the responsibility for training and educating themselves. DoD must adopt a policy that will provide incentives for individuals to improve themselves through education and training. Likewise, institutions must share in this process so that available resources are not squandered.

Policy Requirements (2 of 2)

- **Improvement in analysis training**
  - User training in analysis to leverage integrated decision support / C2 systems (what if'ing)
  - Increased Ops Analysts Training in Battlestaff Support
- **Create ADL and ADS program office to integrate education/training technologies**
- **Increase EXCIMS focus on integration/synthesis/convergence across training/analysis/acquisition M&S programs**
- **Integrate training system development into systems acquisition**

As decision support tools are integrated with command and control systems, there will be a need to improve the training of the users of such tools in traditional analysis techniques. The use of decision support tools to formulate Courses Of Action (COAs), perform wargaming excursions and define strategy must be based upon a fundamental knowledge of analysis. Otherwise, such tools may be misused.

The advent of new technologies will have a profound effect on training and education. Distance Learning (DL) and Advanced Distributed Simulation (ADS) have the potential to revolutionize the training and education process. Such tools will be able to place a user in contact with geographically dispersed knowledge bases and provide new sets of simulation tools that may speed learning and improve retention. Because this technology is so pervasive, it may be prudent to oversee the application of DL and ADS through the formation of a program office that can coordinate the implementation across all of DoD (implementation of the advanced distributed learning initiative).

There are still redundant applications of simulation across the training, analysis, and acquisition areas of DoD. To the extent possible, the EXCIMS should focus on removing the redundancies in those areas and leverage off similar efforts. It is recognized that some efforts in these domains are unique and cannot be leveraged, but may be able to utilize common core M&S pieces.

Management Requirements (1 of 2)

- **Revise training process**
  - Changes in Personnel Management System must be made — can't count on providing most of the training on accession — must train continuously — periodically return to schoolhouse
  - Need to integrate broad based training with tailored training conducted concurrent with operations.
    - Technology changing too rapidly; learning curve too long and specialized (example: SONAR technician with highly specialized skills)
    - Differentiate training based-upon retention requirements (short-time vs. long term)
  - Links to academic (non-military) knowledge sources (universities) — knowledge/training base much expanded

The current training and education process cannot maintain pace with the rapid change in technology. Technology changes demands a rapid, flexible process that can educate the warfighter quickly and satisfy a variety of technical capabilities. A complete revision to the training process must take place that can accommodate these changing needs.

Changes in the personnel management system must be made. Current practices involve training individuals early in their careers with the requisite knowledge that they will need. However, the rapid evolution of technology often makes knowledge obsolete within only a few years. Therefore, the personnel systems must accommodate the need for continuous training throughout the career cycle. The system must make allowances for continuous training and education throughout one's career — not just "frontloaded" at the beginning.

To facilitate this, broadbased training must be integrated with specific, tailored training throughout a soldier's career. An example of broadbased training might be knowledge of basic computer operations that could be used to gain knowledge when necessary. This would allow the user to access more specific information as necessary. Links to non-military establishments (universities, community colleges, etc.) will be necessary to expand the knowledge base for such information.

Management Requirements (2 of 2)

- **Improved synergy between analysis, acquisition and training domains**
  - Use of common resources (simulators for prototyping, determining requirements and training, etc)
  - Change mindset that training objectives are orthogonal to analysis/acquisition objectives
    - Shared data collection between domains without repercussions to individuals
    - Multi-discipline distributed labs
- **Education/training stovepipes must be integrated**
  - Increase synergy between schoolhouses (education) and training community
    - ADL links with institutional schoolhouses

Management of the analysis, acquisition and training domains must be done in such a way that they may share common resources when necessary. Such examples might include the sharing of simulators (for performing virtual prototyping in the acquisition domain, determining requirements in the analysis domain and training operators in the training domain). This will require a change in the mindset that these domains are orthogonal to one another. Data must be easily accessible and shared across domains, without the traditional concerns of releasability of data. The introduction of multi-discipline labs that perform analysis, training and acquisition tasking may help improve synergy across these domains.

Education and training stovepipes must be better integrated in order to support the warfighter. Currently there is little synergy between the education one receives at the service schoolhouses and the training one receives during operations. Again, the rapid pace of technology demands that the education one receives directly supports the training one maintains during operations. ADL could help to integrate these two areas.

Technical Requirements (1 of 8)

- **(1) Create/adopt "open" architectures which allows integration of COTS/GOTS products (HLA?)**
  - Leverage use of products under development in commercial industry (Marine DOOM, Harpoon 97, etc.)
  - Use of multi-national commercial products
  - (DM Amber - DoD influence needed)

It is expected that the commercial world will continue to improve upon simulation applications for the entertainment industry over the next decade. Currently, some of these applications are already approaching and surpassing the fidelity of many military simulations. In order for the military to leverage off of these developments, it will be critical that they conform to the same simulation architecture that has been adopted for interoperability of all DoD simulations (HLA). If the commercial world adopts a different architecture, it will limit the utility of such simulations. Such an architecture must be open to multi-national commercial products, as it is likely that vendors from various countries will develop simulations that will be useful.

Multiple technologies are likely to emerge that will be critical for training applications. An exhaustive list is not provided here, but some of the key technical areas are likely to include the following. Improvements in communications and computer processing should enable long-distance learning/training applications such as ADL. Web-based technologies such as Java should help to provide ease of application sharing across platforms that will lead to improvements in ADL and ADS. Advances in AI will hopefully lead to improvements in human behavioral representation — a key to improving interactive training with simulations.

Technical Requirements (2 of 8)

- **(2) Utilize emerging capabilities**
  - (2a) Communications (CC Green)
    - Bandwidth (however, bandwidth is commercially driven and is NOT limitless)
    - Accessibility
    - Latency (see speed of light...)
  - (2b) Computer processing (CC Green)
  - (2c) Web-based technologies (Java) (CC Green)
  - Interactive Learning
    - (2d) Will technology be there to support it? (IU Amber)
    - (2e) Adapting to personal learning styles/Distributed Learning (Learning theory) (MM Red)
  - (2f) Behavioral representation (MM Red)

Technical Requirements (3 of 8)

- **(3) Digital libraries/repository**
  - (3a) Data/Information Acquisition (IU Red)
  - (3b) Storage (IU Amber)
  - (3c) Accessibility (IU Amber)
- **(4) Security issues must be addressed with increased availability (CC Amber)**
- **(5) Need to model societal effects — political, economic, social issues; non-combative extensions (multi-national, multi-cultural issue) (MM Red)**

The commercial and academic environments will likely lead the way in the application of ADL technologies to promote improvements in learning. In addition to satellite classes, future students may be able to dial up instructional material on demand — allowing them to tailor their education needs as necessary. Such technology could extend to military applications in which soldiers require specific knowledge to complete a task and retrieve it as required.

In order to maximize the benefits of such technology, standards for interoperability will be necessary between DL applications, as well as with ADS applications. Since accessing information from a distance may also involve running simulations to better understand concepts, an integrated architecture between DL and ADS will be required.

With the advent of ADL technologies, access to information will become increasingly easy. However, if sensitive information is also accessible to enemy interests it could easily undermine military operations. Therefore, it is expected that new security methods (multi-level security, improved encryption technologies) will be necessary with the development of such applications.

Technical Requirements (4 of 8)

- (6) Collaboration tools exist (IU Green)
- (7) Develop processes for collaboration tool adoption and use (IU Amber)
- (8) Integration of advanced HCI technology (IU Green)
- (9) Standardization of HCI across military systems (IU Red)

MORS

Technical Requirements (5 of 8)

- (10) Adopt computing platforms driven by commercial standards (CC Green)
- (11) Requirements process (the analysis, understanding, capture and translation to system spec) needs to be reusable (MM Amber)
- (12) CGF application of MM techniques to solve problem of representing the virtual world (XX Red)

MORS

Technical Requirements (6 of 8)

- **(13) Need to unify operational, systems and technical architectures between C4I, M&S and education and training communities to provide a continuum from training, planning, mission rehearsal and execution**
- **(13a) Include training specialists in the acquisition IPT (maintenance, technical support and functional end user [individual and collective]) (MM Amber)**
- **(13b) Reduce training time/resources required for mastery for both trainees and trainers (IU Amber)**
  - (13c) Common infrastructure and standard interfaces to plug and play (DM Amber)
  - (13d) Train on systems we fight on (When training on the real system is the best way to train) (IU Amber)

A major technical goal of the next ten years will be the utilization of an architecture that allows interoperability between C4I systems and M&S. Current technologies do not support such interoperability, without unique hardware (man-in-the-loop in many cases) and software. The goal within the next decade should be to allow the majority of military C4I systems to "plug-in" to the majority of military M&S applications and exchange information without having to build unique interfaces. This will promote the ability to train warfighters on the same C4I systems that they will use in the field, at reduced costs for specialized interfaces to models.

Another M&S training requirement over the next decade will be the collection of performance data on training exercises. Rather than collecting vast amounts of data without regard to which data is important, a strategy of determining the relevant MOEs and MOPs prior to a training event is recommended.

Technical Requirements (7 of 8)

- **(14) Need to collect data on training performance**
  - (14a) Should be theory driven (don't collect data for sake of collection) (IU Red)
  - (14b) Need for instrumentation of systems (technical and human) to collect meaningful quantitative and qualitative measures of training efficiency/effectiveness (IU Red)
  - (14c) Operational community must allow training effectiveness to be measured with individual/team attribution) (IU Red)

Technical Requirements (8 of 8)

- **14 (Continued)**
  - (14d) Need increase measurability of existing performance standards (UJTL/Mission Essential Tasks) (IU Amber)
  - (14e) Develop equivalent performance standards for the acquisition and analysis communities (IU Amber)
  - (14f) Need to develop training effectiveness measurement tools (IU Amber)

Equally Great Thoughts...

- **Need to promote research in new training methodologies**
- **Need to respond to new training methodologies with new training technologies**
  - New technologies support an expanded training space
    - Train skills we can't train today
    - Use training methods not possible today
- **Don't wait to begin to exploit, otherwise will never get there**

The influx of new technologies for training will also require new methods of training in applying them. We must adopt methods that will help us change the WAY we learn in addition to what we learn. New learning methods that stress the ability to assimilate information will likely be required, instead of traditional methods that focused on memorization or repetition.

It is critical that we begin to exploit these new technologies as soon as possible. The rapid evolution of technology will tend to make detailed, long-to-develop plans obsolete before they can be implemented. Instead, we should begin to focus on how we can utilize emerging technologies and gain experience in applying them that can be built upon.

Technology Assessment (1 of 2)

	ITEM/ISSUE	MM	DM	CC	IU	COMMENTS
1	Create/adopt "open" architectures which allows integration of COTS/GOTS products		A			Requires acceptance of DoD standards by commercial market place
	Leverage use of products under development in commercial industry (Marine DOOM, Harpoon 97, etc.)		G			Requires continued emphasis
	use of multi-national commercial products		A			(DoD influence needed)
2	Utilize emerging capabilities					
2a	Communications			G		
	Bandwidth (however, bandwidth is commercially driven and is NOT limitless)			G		
	Accessibility			G		
	Latency (see speed of light...)			G		
2b	Computer processing			G		
2c	Web-based technologies (java)			G		
	Interactive Learning					
2d	Will technology be there to support it?				A	We need to define it first
2e	Adapting to personal learning styles/Distributed Learning (Learning theory)					No program or theory; developing learning theory
2f	Behavioral representation					No viable HBR theory
3	Digital Libraries/Repository					
3a	Data/Information Acquisition					No structured program
3b	Storage				A	No one is funding containers
3c	Accessibility				A	Creating infrastructure and mechanisms to retrieve info

Technology Assessment (2 of 2)

	ITEM/ISSUE	MM	DM	CC	IU	COMMENTS
7	Develop processes for collaboration tool adoption and use				A	Cultural barriers; How to best use collaboration
8	Integration of advanced HCI technology				G	Driven by commercial industry
9	Standardization of HCI across military systems					Not standardized; Cultural barriers
10	Adopt computing platforms driven by commercial standards			G		
11	Requirements process (the analysis, understanding, capture and translation to system spec) needs to be reusable	A				W/DoD influence; commercial proprietary nature; exploitation problem
12	CGF application of MM techniques to solve problem of representing the virtual world					No DoD program; No complete theory for HBR
13	Need to unify operational, systems and technical architectures between C4I, M&S and Education & Training communities to provide a continuum from Training, Planning, Mission Rehearsal and Execution...					
13a	Include training specialists in the acquisition IPT (maintenance, technical support, and functional end user [individual and collective])	A				Significant cultural barriers
13b	Reduce training time/resources required for mastery for both trainees and trainers				A	Lack of training theory
13c	Common infrastructure and standard interfaces to plug and play		A			Evolution of system/technology increases requirement; Technology green, Operations amber
13d	Train on systems we fight on (When training on the real system is the best way to train)				A	Not always best training available; Resources often unavailable due to OPS
14	Need to collect data on training performance					
14a	Should be theory driven (don't collect data for sake of collection)					No structured program; no theory for collection
14b	Need for instrumentation of systems (technical and human) to facilitate collection of meaningful quantitative and qualitative measures of training efficiency/effectiveness					No structured program; no theory for collection
14c	Operational community must allow training effectiveness to be measured with individual/team attribution (on a not-to-interfere-with-operations basis)					No structured program; no theory for collection
14d	Need to improve (increase measurability of) existing performance standards (UJTL/Mission Essential Tasks)				A	Moving in that direction
14e	Develop equivalent performance standards for the acquisition and analysis communities				A	Moving in that direction
14f	Need to develop training effectiveness measurement tools				A	Moving in that direction

Report of the
Technology Assessments Working Group

Participants

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Expert Opinions

Predicting the distant future is easy. Solar power will be harnessed, cures will be found for present-day diseases, and the New York Mets will win the World Series. The real difficulty is predicting tomorrow — figuring out the next step in getting from where we are to where we are going....Arthur Miller of Motorola Inc. in IEEE Spectrum June, 1994

Always listen to the experts. They'll tell you what can't be done and why - then do it....Robert A Heinlien

A conclusion is the place where you got tired of thinking....Unknown

At best, predicting the future is problematic. At worst, it is a waste of time. Consequently, we will not attempt to predict the future, but rather attempt to make bounding estimates concerning where technology might be 10 years from now given certain assumptions about ongoing DoD spending and the directions that may be taken by commercial information technology development.

Definitions*

- **Conceptual Model: A statement of the content and internal representations which are the user's and developer's combined concept of the model. It includes logic and algorithms and explicitly recognizes assumptions and limitations.**

- **Model: A physical, mathematical or otherwise logical representation of a system, entity, phenomenon or process.**

- **Simulation: A method for implementing a model over time.**

- **Modeling and Simulation (M&S): The use of models, including emulators, prototypes, simulators and stimulators, either statically or over time, to develop data as a basis for making managerial or technical decisions. The terms "modeling" and "simulation" are often used interchangeably.**

* *Extracted from DMSO M&S Glossary*

These foundational definitions are provided to aid in this presentation on modeling and simulation technology

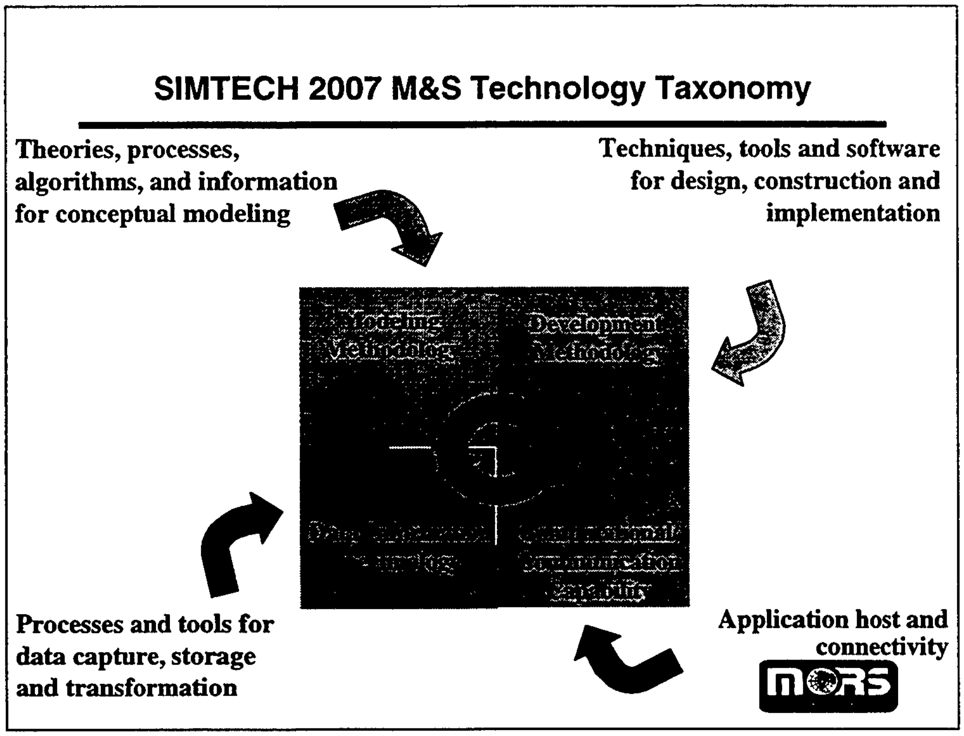
Conservative and Aggressive Prediction
-- Definitions --

- **Conservative Predictions: Assumes that the area maintains its current trend***
- **Aggressive Predictions: Assumes that the trend for the area increases substantially***

** Either in DoD or commercial sectors*

Our conservative predictions assume that current priorities and funding levels for M&S technologies remain constant and that the current rate of improvement in M&S technology development continues.

Our aggressive predictions assume that the area of M&S technology receives substantially higher priority and funding. Also, we assume that the rates of advance in M&S technology increase because of increased funding or because of unexpected breakthroughs.



The formulation of this taxonomy of M&S technology was undertaken to support SIMTECH 2007. It is not necessarily a decomposition that would be preferred for other types of examinations of information application domains and their related technology. These top-level bins are are further divided into subcategories to support the detailed deliberations of SIMTECH 2007.

Modeling methodology: Includes the theories, processes, algorithms and information that support the conceptualization of a model.

Development methodology: Includes the techniques, tools and software used in the design, construction and implementation of models or model tool sets.

Data and information technology: Includes the processes and tools for the capture, storage, transformation and understanding of data and information.

Computation and communications capability: Includes the systems on which the M&S application will be hosted and how the M&S application connects to other M&S applications.

Current State of Simulation Technology

- **Modeling methodology**
  - Most recent focus on high resolution, entity based technologies
  - Simulations still to hard to use
- **Design methodology**
  - Simulations = software;
  - Standards are limited, most standards in use are commercial
- **Computational and communications capability**
  - A limiting factor, but not by much
- **Data and information technology**
  - Analysis is an art, not a science
  - Collaboration tools are maturing

MORS

Modeling methodology: Most recent focus is on high-resolution, entity based, human-in-the-loop technologies; there is little real investment in other areas. There are few to no advances in Computer Generated Force (CGF) technology. Simulations are still hard to use and it is too hard to understand the results. Users becoming more comfortable, but still very reserved.

Design methodology: Simulation = software; nothing more to say. Large scale simulation systems exceed the communities' ability to specify and build. Standards (especially for interoperability and reuse) limited to HLA and SEDRIS; most standards in use are 'owned' by the commercial sector.

Computational and communications capability: A limiting factor, but not by much.

Data and information technology: No efforts to instrument and collect raw data. Scenario generation is a limiting factor. Analysis is an art, not a science. Collaboration tools are maturing and they are beginning to help requirements management.

Modeling Methodology

- **The theories, processes, algorithms and information that support the conceptualization of a model**
  - Representations; e.g.,
    - Cognitive
    - Physical Effects
    - Decision support (C2)
  - Simulation techniques; e.g.,
    - Computer Generated Force (CGF) techniques
- **Requirements**
  - Requirements analysis, capture and understanding
  - Translation of system requirements to system specification

MORS

The area of Modeling Methodology includes:

Representations:

Cognitive (e.g., perception, planning, reasoning, understanding)

Classical warfare; emerging warfare areas (e.g., information warfare, asymmetrical warfare, peace keeping operations, small unit operations)

Performance modulators (e.g., fear, fatigue, skill level)

Physical effects (e.g., environmental representation, movement, attrition, resource consumption)

Decision support (C2), doctrine, organizational modeling

Simulation Techniques:

Computer generated forces techniques, the "how" of the "what." The modeling methodologists need to understand the implementation concept.

Requirements:

Requirements analysis, capture and understanding

Translation of system requirements to system specification

Modeling Methodology
-- Conservative Predictions --

- **Representations:**
  - Cognitive/modulators
    - Approaches remain *ad hoc*
    - Limited advances in emerging warfare areas
  - Physical:
    - Increasing fidelity in these areas
    - Limited ability to model C2
- **Simulation techniques**
  - Few new AI techniques developed; no real advances in CGF technology
- **Requirements**
  - Analysis, capture and understanding
    - Continues to be underfunded
    - Still difficult; essentially a manual process

Representations: Business as usual: under-funded/-emphasized/-prioritized

Cognitive/modulators: Approaches remain *ad hoc,* fragmented and uncoordinated. There are limited advances in emerging warfare areas. Research on human perception is limited (adversarial modeling).

Physical: Effects and environmental representation: improves, increasing fidelity in these areas, yet pieces are not fully integrated. There is limited ability to model C2 structures, doctrine and tactics.

Simulation techniques: Few new AI techniques are developed; there are no real advances in CGF technology.

Requirements: Analysis, capture and understanding. Continues to be underfunded. Simultaneously, this becomes a harder issue because of changes in the world (e.g., very limited ability to model non-conventional warfare). The translation of requirements to system specifications is still difficult; essentially a manual process.

Modeling Methodology
-- Aggressive Predictions (1 of 2) --

- **Representations**
  - Representation of cognitive/modulators: Program, as recommended in SIMTECH 97, is undertaken, giving rise to coherent, community-accepted models
  - Perception modeling/adversarial modeling matures (but not perfect)
  - Physical effects: Matures to point conventional and emerging warfare effectively covered

More

Representation of cognitive processes and modulators progresses. The program, as recommended in SIMTECH 97, is undertaken, giving rise to coherent, community-accepted models.

Perception modeling and adversarial modeling matures, but not perfect

Modeling moves in one of two directions; large scale, general purpose simulations become institutionalized, or boutique' models becomes the norm. If the latter, component interoperability will be required.

The modeling of physical effects matures to the point that conventional and emerging warfare are effectively covered. Tools to generate geo-typical (but geo-specific representative) will mature and generation of geo-specific representations is fast but still expensive.

Modeling Methodology
-- Aggressive Predictions (2 of 2) --

- **Simulation techniques**
  - Variety of new innovative technologies matured; full-up, general purpose CGF probably not yet fully realized
- **Requirements**
  - Analysis and understanding of underlying "physics"
  - Translation of requirements to system specification

Simulation techniques: A variety of new innovative technologies matured, although full-up, general purpose CGFs are probably not yet fully realized. There is reduced emphasis on knowledge acquisition and knowledge engineering.

There is increased computational efficiency.

There are significant advances in the ability to model human-to-human interactions.

Requirements: The analysis and understanding of underlying "physics" becomes a priority issue. Investment in this area is increased substantially, however, this area remains an art form vice a science.

The translation of requirements into system specification experiences breakthroughs that support automated linking of requirements to system specifications.

Development Methodology

- **The techniques, tools and software used in the architecting, design, construction and implementation of the models or the model tool set**
  - System composability (e.g., Object-Oriented, component technology)
  - Simulation frameworks and componentware (e.g., SPEEDES, SIMSCRIPT, Flames, DEVS)
  - Standards for design, interoperability and reuse

Development Methodology includes the techniques, tools, and software used in the architecting, design, construction and implementation of the models or the model tool set. This area includes concepts such as:

System composability which is achieved through the use of object-oriented and component technology.

Simulation frameworks and componentware such as SPEEDES, SIMSCRIPT, Flames, DEVS.

Standards for design, interoperability and reuse.

Development Methodology
-- Conservative Predictions --

- **Composable technology**
  - Continues to develop
- **Simulation frameworks**
  - Continue to develop slowly; system level programmers still control programs
- **Standards**
  - Largely commercially driven (e.g., VRML)
  - Interoperability and reuse of military simulations remains difficult

Composable technology will continue to develop. For example, there will be more use of object-oriented techniques for model construction and there will be maturing of component technology.

Simulation frameworks will continue to develop slowly. System level programmers (C++ programmers) still control our programs. There are no new simulation or simulation friendly languages on the horizon.

Standards are largely commercially driven (e.g., VRML). Interoperability and reuse of military simulations is aided by the continued maturing of HLA and SEDRIS. However, there are no new standards in areas such as CGF behaviors. Software reuse on a significant scale continues to be limited and difficult to achieve.

Development Methodology
-- Aggressive Predictions --

- **Composable technology**
  - Development leads to iconic model construction
  - 'Boutique' simulation becomes viable
- **Simulation frameworks**
  - Use becomes commonplace; will aid interoperability and reuse
- **Standards**
  - Still commercially driven,
  - Interoperability and reuse see some new work beyond HLA and SEDRIS

Composable technology development leads to iconic model construction. This enables more reuse across functional areas. True rapid prototyping and 'boutique' simulation become viable.

The use of simulation frameworks becomes commonplace. This will aid interoperability and reuse, but only within systems using the same frameworks except as enabled by component technologies.

Standards are still commercially driven, new standards may evolve out of communication/ entertainment communities.

Interoperability and reuse are advanced by some new work beyond HLA and SEDRIS, however, because of the time lag in standards there is little impact in the speed-up of development and deployment over the next 10 years.

Computational and Communications Capability

- **What the M&S application will be hosted on, how it connects to other M&S applications and how M&S application developers and users connect to one another**
- **Computing platform**
  - Computing power
  - Network Connectivity (e.g., bandwidth requirements for complex simulations)
  - Security (e.g., security protocols)

The area of computational and communications capability includes the system that will host the M&S application, how it connects to other M&S applications and how M&S application developers and users connect to one another.

This area addresses the computing platform computational power. Also included are the network and the associated bandwidth requirements for complex simulations; the tools for setting up and maintaining the network; the simulation or simulator building techniques for distributed computing; and system security, for example, security protocols, especially for multi-level security.

Computation and Communications
-- Conservative Predictions (1 of 2) --

- **Computing platform:**
  - Still mainly PC/workstation environment
  - However, wireless computing begins to be more common
- **Computing power**
  - Increase on average twice as fast as Moore's Law
- **Network**
  - Backbone is 10 Giga-bit
  - Setting up a network continues to be a complex, difficult task

More

Computing platforms are still mainly PC and UNIX workstation environment, however, wireless computing begins to be more common.

Computing power sees average increases at a rate that is twice as fast as Moore's Law.

Network backbones will be 10 Giga-bit (OC192). The next generation Internet protocol emerges. T1 connectivity to the home is the norm. However, setting up a network continues to be a complex and difficult task.

There are reductions in the manpower required to develop networking solutions. There are reduction in costs associated with hardware for routers and leased phoned lines. New techniques emerge to reduce M&S setup time and to reduce network resource requirements. Solid solutions will exist for connecting multiple computers and multiple computer users to support collaborative work (e.g., ATM, multi-casting, Internet model).

Computation and Communications
-- Conservative Predictions (2 of 2) --

- **Distributed computing**
  - More common place — networkable computers increases computing power
  - Distributed simulation bandwidth needs still require high speed, expensive networks
- **Security:**
  - Concerns begin to be addressed; still fall short
  - (e.g., multi-level security is not achieved)

Distributed computing becomes more common place, networkable computers increase computing power. Distributed simulation bandwidth is still an issue, high speed expensive networks are still required.

Security concerns begin to be addressed but still fall short, for example, multi-level security is not achieved.

Computation and Communications
-- Aggressive Predictions (1 of 2) --

- **Computing platform**
  - Workstations disappear, PC-based systems the norm
- **Computing power**
  - Grows at a rate at least four times Moore's Law
- **Networks**
  - Backbone is 500 Giga-bit
  - Difficulty in establishing a network considerably improved
  - Some improvement in simulation bandwidth efficiency

More

The typical computing platform is a light weight PC-based system and workstations have disappeared. Nomadic, wireless, personal data assistants are in regular use.

Computing power grows at a rate at least four times Moore's Law.

The network backbone is 500 Giga-bit. There is good bandwidth to overseas locations, making CONUS-to-global distributed simulation much more accessible. There is considerable improvement in alleviating the difficulty in establishing a network. Automatic establishment of a network (networks on-demand) is close but not yet available.

There are some improvement in simulation bandwidth efficiency, but due to cost and availability of networks this area has low priority.

Computation and Communications
-- Aggressive Predictions (2 of 2) --

- **Distributed computing**
  - Networks, computers, simulation systems are much more distributed and computing friendly
- **Security**
  - Adaptive security software developed to address many or most security concerns
  - However, perfect solutions still do not exist

Distributed computing is greatly aided by networks, computers and simulation systems that are more distributed and computing friendly. The decision to operate local-only or distributed is not based on difficulty of setting up and running distributed exercises.

Solutions will be developed for the global addressing problem of data distribution within simulation transport infrastructure aiding HLA RTI, SPEEDES and other interoperability mechanisms.

Communication requirements between distributed components will be drastically reduced. Techniques will be developed for performing *a priori* resource requirements analysis to support pre-exercise load balancing of simulation objects across computation resources.

Security solutions for multi-level simulation exercises emerge. Adaptive security software is developed to address many or most security concerns. Users are not faced with obstacles such as rebooting, switching hard disks or continually downloading patches to security system software. However, this is a very difficult area and perfect solutions still do not exist.

Data and Information Technology

- **The processes and tools needed:**
  - To acquire and transform data/information
  - For data/information storage and retrieval
  - To understand the model and its results
- **Includes processes and tools for:**
  - Data acquisition, capture and storage
  - Transforming the data into useful applications (e.g., scenario generation)
  - Presenting, understanding and collaborating on the M&S application and its results

The area of data and information technology includes the processes and tools needed to acquire and transform data and information and for data and information storage and retrieval. This includes data for model creation and reuse libraries for simulation, model, scenario and AAR and Analysis data.

This area also includes the handling of data and information needed to understand models, and the results of their use.

Also included are the processes and tools: for data acquisition, capture and storage; for transformation of the data into useful applications, for example, scenario generation; and for presentation, understanding and collaboration on the M&S application and its results. This last area includes: the Human Computer Interface (HCI) (how the application appears and how you interact with it); analysis techniques (how you understand the data); and collaboration tools and environments. Collaboration tools enable the ability to connect developers and users together for model development, scenario development, and other purposes.

The current state-of-the art: I/O: screens, mice and keyboard most commonly used; limited use of audio; few haptic devices; close coupling of computer and I/O devices; some research available on human perception of information; desktop and windowing paradigm for presentation which is predominantly 2D graphics with increasing use of 3D.

Data and Information Technology:
-- Conservative Predictions --

- **Data acquisition, capture, and storage:**
  - Continues to be fragmented, ad hoc and of low priority
- **Transforming data into useful applications**
  - Some automation but still a largely manual, time-consuming process
- **Presentation, understanding, collaboration:**
  - HCI: Screens, mice, and keyboards replaced by voice input, light pens, electronic notepads;
  - Collaboration tools/environments are part of overall system design

Data acquisition, capture and storage continues to be fragmented, *ad hoc* and of low priority. There is little improvement in being able to find, access and understand raw data. Data base technology is not the limiting factor, desire and funding is.

Transforming data into useful applications, like scenario generation, sees some automation but is still a largely manual, time-consuming process. The ability to take advantage of M&S to support crisis response is still more talk than action.

Presentation, understanding and collaboration through the HCI matures. Screens, mice and keyboards are replaced by voice input, light pens and electronic notepads.

Analysis techniques is aided by user interfaces that are optimized to ease analysis of simulation results. The ability to understand simulation outputs is still an art versus a science.

Collaboration tools and environments are part of overall system design and real-time Video TeleConferencing (VTC) and whiteboarding is ubiquitous.

Data and Information Technology
-- Aggressive Predictions (1 of 2) --

- **Data acquisition, capture and storage**
  - More systematic instrumentation of experiments and events
  - Database and data warehouse technologies mature
- **Transforming data into useful applications (e.g., scenario generation)**
  - Techniques mature to automate finding relationships in raw data
  - Rapid scenario generation technology maturing

More

In the area of data acquisition, capture and storage there is more systematic instrumentation of selected key experiments and events. The storage of resulting products in data warehouses. Database and data warehouse technologies mature via commercial sector needs.

Transforming data into useful applications sees techniques mature to automate finding relationships in raw data. Rapid scenario generation technology is maturing and the ability to implement within next generation simulation systems is realizable.

Data and Information Technology
-- Aggressive Predictions (2 of 2) --

- **Presentation, understanding and collaboration:**
  - HCI: Gesture and haptic devices mature
  - Analysis: Moving towards automatic analysis; focus is on scenario design, not analysis of results
  - Tools mature to the point were VTC and virtual collaboration is the norm

For presentation, understanding and collaboration — HCIs include mature gesture and haptic devices.

For analysis — technology is moving towards automatic analysis with the focus on scenario design, not analysis of results. Non-simulation trained users are able to become active users of the technology. Tools mature to the point were VTC and virtual collaboration is the norm. This is commercially driven and results in traveling for business meetings being down 25%.

Commercial Technology Trends (1 of 4)

- Modeling Methodology
- Internet gaming and Internet simulation
- General purpose computer gaming
- Perception modeling
- 3-D capture devices and applications: 3-D sound
- Interactive multi-media: Video on demand
- Situation analysis

Commercial business is driving the listed technologies. It is likely that these technologies will have value to DoD M&S developers and users. It is unlikely that DoD will need to do more than use or participate in the use of these technologies. DoD project offices may develop relationships with certain vendors to extend their product capabilities.

Commercial Technology Trends (2 of 4)

Development Methodology

- **Simulation frameworks**
- **Intelligent agents**
- **Automatic programming**
- **Component technologies**

Commercial business is driving the listed technologies. It is likely that these technologies will have value to DoD M&S developers and users. It is unlikely that DoD will need to do more than use or participate in the use of these technologies. DoD project offices may develop relationships with certain vendors to extend their product capabilities.

Commercial Technology Trends (3 of 4)

Computation and Communications

- Internet (telecommunication/commerce)
- Personal/portable computing (appliance computing
- Voice recognition
- GPS everywhere, in everything
- Video on Demand
- Flat panel displays/head mounted displays
- Very low cost, high speed, high resolution, networked computers in 50% of US homes
- Long life batteries (increased portability)

Commercial business is driving the listed technologies. It is likely that these technologies will have value to DoD M&S developers and users. It is unlikely that DoD will need to do more than use or participate in the use of these technologies. DoD project offices may develop relationships with certain vendors to extend their product capabilities.

Commercial Technology Trends (4 of 4)

Data and Information Technology

- **Knowledge management**
  - Data Mining of large data sets
  - Nano-technology (instrumentation/data collection)
  - Databases and utilization tools
  - Data Visualization
- **Virtual meetings (VTC, collaboration, chat rooms)**
- **Planning, scheduling and resource allocation**
- **High resolution, low cost satellite imagery**

Commercial business is driving the listed technologies. It is likely that these technologies will have value to DoD M&S developers and users. It is unlikely that DoD will need to do more than use or participate in the use of these technologies. DoD project offices may develop relationships with certain vendors to extend their product capabilities.

Report of the Synthesis Working Group

This talk is a short set of musings with the flavor of synthesis. It is not an attempt to summarize the summaries, or to comprehensively review the work of the overall workshop. Despite this caveat, it seems that there is a pattern to what is in the air, if merely we listen to it correctly.

Participants

Paul Davis, Co-Chair
Clayton Thomas, FS, Co-Chair

Something Worthy of Being Called a "Requirement" for M&S 2007

- **DoD's M&S must support:**
- **(1) Adaptive planning**
- **(2) Commanders' concerns for risk and uncertainty, including**
  - That related to smart enemies using clever and perhaps asymmetric tactics
  - And that related to complex and nonlinear phenomena
- **and**
- **(3) Transforming the force for future warfare by facilitating innovation, testing, and refinement of operational concepts for parallel, time-compressed, network-centric operations dependent less on classic head-on-head attrition battles than on maneuver of disparate capabilities (forces, fires, IW, defenses,...) to destroy or otherwise defeat adversaries**

The word "requirement" is often used in disastrous ways in large organizations, but it is a useful word nonetheless. This slide suggests a unifying "requirement" for DoD's M&S. The essence is that if M&S is to be useful, it must support — and not merely at the level of lip service — adaptive planning, assessment of risk and uncertainty and innovation.

With Apologies for Using the "P" Word, This Requires Some Paradigm Shifts

- **Planning for adaptiveness becomes fundamental: Planning for standard scenarios becomes old-think**
- **"Baseline cases" or even "best estimates" don't hack it**
- **Modeling dumb enemies — or superman enemies — is counterproductive**
- **Models that constrain thinking or teach rigidity are dysfunctional and have negative value**
- **Models should perhaps be built around command and control, networks and systems of systems, not around platforms or units**

If we take the requirement seriously, it has many implications. This slide mentions only some of them, but they may be sufficient to demonstrate that the implications involve something a good deal more than changes on the margin.

Themes Suggested for the Style of Analysis

- **Exploratory analysis in a broad scenario space (related to capabilities-based planning)**
- **Examining uncertainty to highlight risks to be reduced**
- **Exploiting humans for both creative inputs and insightful exploratory review**
- **Connecting to users, spiral analysis,...**
- **Distributed collaboration in development, analysis and operations**

Suppose, then, that we accept the need for deep changes. What kinds of analysis will we find ourselves doing if we rise to the challenges? This slide mentions some of the key themes. The need for adaptiveness and the ability to deal with risk and uncertainty should drive us toward exploratory analysis and away from analysis that purports to be accurately predictive or optimizing. It drives us toward analysis in which "probability" distributions are sometimes prominent, and in which the focus is on understanding "tails" and "blips," not merely alleged central tendencies. It drives us toward analysis that support the search for robustness, flexibility, and adaptiveness.

Both to understand uncertainties and to better understand our own potentialities, analysis must actively support the creative process. If M&S does not facilitate creation and study of innovative operational concepts, then it may be counterproductive, not "merely" dysfunctional. But this implies — if experience is our guide — that M&S must actively and enthusiastically link with humans. M&S should include human war games and optionally interactive simulations (e.g., live Blue command-level play versus smart Red models). It should be flexible enough to represent the full range of strategies and tactics, and the full range of important factors — whether or not they lend themselves well to predictive mathematics. And they should lend themselves well to reflecting insights from human play in "smart" models. This, in turn, suggests close connectivity between modelers, analysts and operators, a connectivity exploited iteratively — in a "spiral" process — rather than in anything more neat. And, finally, it suggests great emphasis on collaborative methods allowing the appropriate collaborations and competitions.

Enabling Science and Technology

- **Warfare area research (precision fires, missile defense, littoral warfare,...; transnational threats,..critical infrastructure...?)**
- **Basic research on M&S methodology, environments, tools, and standards**

If we have a sense of the "requirement" and the form that analysis should take, what about the enablers? This slide reminds us of a recurring theme of the workshop: that there is need not only for "technology," but also for an enriched base of military science and an enriched base of methodology.

Drawing in part on work reported elsewhere (National Research Council, "Modeling and Simulation," Volume 9 of "Tactics and Technology for the United States Navy and Marine Corps, 2000-3035," National Academy Press, 1997), we see the need for two kinds of research. If we are to harvest the fruits of fundamental research (e.g., on cognitive science or complexity theory) for the DoD's needs, we need application-focused research, which might be organized around major subjects in next-generation military operations. Each such warfare area has its own phenomena, which are much more complex and subtle than one would ever imagine from the usual viewgraph-level discussions. Each such area deserves a research base, but one that might take 10 years to develop — with scientists (not just programmers) working closely with operators and with those developing and testing new concepts and systems. Creating such warfare-area research programs could be a relatively inexpensive but powerful enabling activity for the DoD. The key agencies should be DARPA and DDR&E/DMSO.

Although there is a great deal of fundamental science that begs to be exploited in warfare-area research programs, profound problems also exist, problems that are simply not well understood yet and that deserve many years of study. These involve concepts of M&S, M&S environments (including optimal use of interactiveness) and tools generally. We should not assume that the commercial world will provide all that is needed here, although there are very nice tools that have emerged.

Subjects for Both Fundamental and Applied Research (1 of 2)

- **Agent-based modeling, search and model building**
- **Variable structure simulation**
- **MRM (MultiResolution Modeling), families of models**
- **Cognitive modeling (representational formalisms, capturing cognitive maps, ...[not how brain works])**
- **Role of interactiveness in discovery, definition, analysis, ...(man-machine partnership) (HCI)**
- **Modeling around deep knowledge (declarative plus some procedural) rather than algorithms**
- **Representation for and reasoning about network-centric systems**
- **Primers on M&S for domain experts and analysts**
- **Distributed learning; collaborative tools; digital libraries; cross educating for training, analysis,...**

If we now turn from generalities to "name level" subjects that seem to be particularly relevant to our image of analysis needs, we see the items in this slide. If there are to be major changes of the sort needed, then these are key subjects that seem to offer the needed types of promise. Agent-based modeling is closely related to models of both decision making and behavior; it is closely related to giving M&S the capacity to adapt to circumstances, and even to reorganize and self-organize. Variable-structure simulation is not well studied as yet, although some books on the subject exist.*

Agent methods are also needed for exploratory analysis — to help make sense of results in huge outcome spaces that reflect uncertainty. They can help with inverse questions such as "Under what circumstances would we do well?" These, rather than "What if?" questions, become central. And agents could be used actually to build "models," to infer from simulation outcomes and empirical work with human players what factors are most important and even what cause-effect processes seem to dominate. In this domain and in others as well, we believe a fundamental element of success will be interactiveness. At least for the foreseeable future we believe that progress will be most feasible where the man-machine partnership is developed, where model-building or outcome-exploring agents are strongly guided by insights, intuition, and flat-out guesses from human domain experts. This is drastically different from mere statistical analysis as currently practiced, but also very different from the vision of computers making sense of chaos by themselves.

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*For the purposes here, "agents" are simulation objects that serve as surrogates for or agents of humans. One kind of agent is a decision model representing a commander. A second kind serves the analyst by watching for states to arise at which it will intervene to change parameter values or even structural features of the simulation in the same way an analyst might do interactively if watching state changes continuously on some imaginary display. As noted, many different functions can be served by agents. Agents are implemented in many ways. Some look like I/O programs; others use A.I. methods such as branched scripts or production rules; still others use methods sometimes associated with artificial-life studies (e.g., cellular automata). These implementation details are less important here than the functions served.

Subjects for both fundamental and applied research (2 of 2)

- Agent-based modeling, search and model building
- Variable structure simulation
- MRM (multiresolution modeling), families of models
- Cognitive modeling (representational formalisms, capturing cognitive maps, ...[not how brain works])
- Role of interactiveness in discovery, definition, analysis, ...(man-machine partnership) (HCI)
- Modeling around deep knowledge (declarative plus some procedural) rather than algorithms
- Representation for and reasoning about network-centric systems
- Primers on M&S for domain experts and analysts
- Distributed learning; collaborative tools; digital libraries; cross educating for training, analysis....

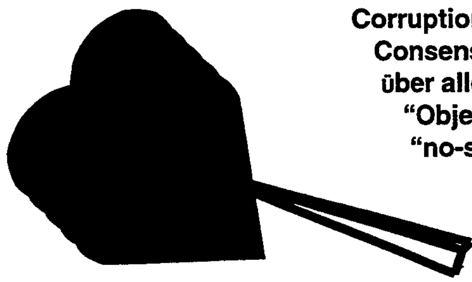
So also multiresolution modeling, both within single models and families of models, is fundamental to a rich understanding in any warfare domain. Moreover, it is a key element of dealing with complex adaptive systems (such as warfare) in which phenomena may have "laws of their own" at different levels.

The next item refers to focusing human efforts on the expression of "deep knowledge" rather than particulars of problem solving. It is far more powerful to express knowledge in a form like Maxwell's Equations, and allowing computers to find solutions for particular situations, than to have humans specify for the computer how to solve each new electromagnetics problem. So also, there is enormous power in conservation laws. The analogs in the military domain include representing objectives, components, and constraints (e.g., mission orders, tactical building-block operations and constraints imposed either by choice or the situation). Importantly, this modeling around deep knowledge rather than algorithms is not the same as the computer-science distinction between declarative and procedural knowledge, because some of the key knowledge is in fact procedural. This is evident in real-world operations, which depend on combining building-block operations in particular ways, not start-from-scratch activities. This said, one of the most challenging modeling problems is how to represent and deal with "network" systems where important properties of the network are "emergent" and not well understood. This is becoming a crucial issue as US military operations become more network centric and more dependent on M&S embedded in the command and control system.

If man-machine partnerships are essential, as they are in command and control, then collaborative work can be enriching and even essential. This, in turn, will depend upon the ability to share information, models and analyses easily. The methods currently being used for lifelong learning and distributing learning seem highly relevant here, especially if the future will include our wanting quickly to be able to comprehend and try out models that others somewhere in cyberspace have developed.

Stake-Driving Needed

Central Planning
Bureaucratic VV&A
Corruption for advocacy
Consensus and consistency über alles
"Objectivity" worship (as in "no-soft-factors here!")



The last two slides are somewhat different in character, but are again efforts to capture key ideas floating through the workshop. This slide notes that current M&S-supported analysis is severely hampered by what many see as DoD's tendencies — especially in the last ten years — to approach M&S matters with excessive controls, bureaucracies, processes and procedures — many of which seem to serve the needs of advocacy or don't-rock-the-boat thinking than the needs of innovation or the search for insight. This point is becoming more widely recognized by senior people in the community, including decision makers. Related discussion can be found in the 1996 DSB summer study report (Vol. 2), in the opening talk to the workshop by General Larry Welch (USAF, retired), and in many other documents. What is new is that more senior figures appear to be aware of the problems.

Problem: how to control control (helping, not hurting)

Desirable	Undesirable
Enabling standards (MIME, ...HLA)	"Blessed" models, data bases, stamping out "redundancy"
Subsidizing infrastructure creation (with broad architecture)	Specifying detailed character of infrastructure
Base cases for comparison	Treating base cases as meaningful best estimates
Infrastructure for distributed collaboration	"Blessed" federations
Connecting modelers with operators and other users	Laundry-list "requirements" from operators and other users
Requirement to treat soft factors	Requirement to model cognition, physiology...

Finally, this slide suggests some important distinctions that may help in attempting o move forward. These are, for example, the distinction between having enabling standards (e.g., the MIME standard making cross-platform e-mail possible, or the HLA) versus having shackles such as insistence on the use of bureaucratically "blessed" models and data bases, whether or not appropriate, or having active efforts to stamp out alleged redundancy, which has the effect of stamping out the competition of ideas so necessary for progress.

The other examples can be read as they stand. The bottom line here is that we must all recognize that many of the initiatives that could be of greatest value to the community and the policymakers we serve bring with them "dark-side" features that, if not controlled, can make things worse rather than better. At the same time, being against the initiatives because of the potential bad actions will doom the community to increasing irrelevance and incompetence.

Report of the
Life Cycle Management Working Group

MORS

Participants

Bruce Bennett, Co-Chair
Bob Statz, Co-Chair

Jesse Aronson
Howard Carpenter
Denis Clements
CAPT Lee Dick
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COL Crash Konwin
Dell Lunceford
Richard Modjeski
Steve Olson
Ernie Page
Annie Patenaude
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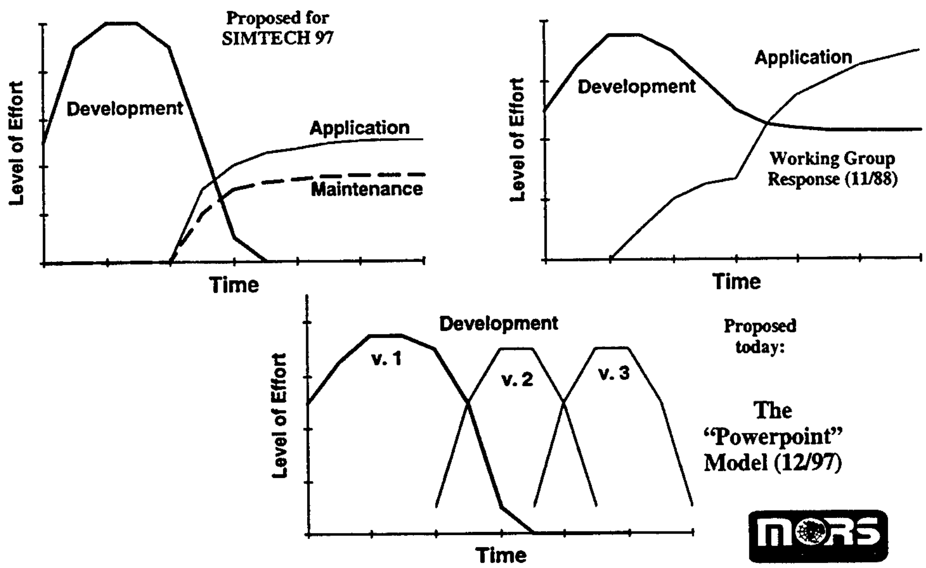
What Was Said (11/88): SIMTECH 97 Findings

- **Tasking sought to use technology to solve a range of life cycle management issues**
- **Working Group concluded that technology was a tertiary issue, that by itself**
  - Doesn't solve many existing problems
  - Will not provide desired enhancements
- **Instead, community needs to address management and implementation issues**
  - Need to resolve these issues to take advantage of technology
  - Need a more appropriate life cycle model

Alternative Life Cycle Views



Elements of the Life Cycle Discussed in SIMTECH 97 (11/88)

- **Human capital**
  - Development skills (functional and software)
  - Analysis skills
- **Military knowledge base**
  - Basic research
  - Aggregation/abstraction
- **Sponsor interactions**
  - Substantive support
  - Appropriate expectations
- **Implementation environment**
  - Hardware
  - Software

What Did SIMTECH 97 Do Well On Life Cycle Management?

- **Technology didn't and won't solve many life cycle management issues; M&S management/implementation issues dominated**
  - Identified many of the key issues that impaired the capabilities of military simulations
  - Some have been partially addressed since SIMTECH 97 (e.g., scenario development software, DMSO, ...)
  - Some issues remain as problems today
- **Assessment that the role of domain experts is key**
  - But DoD does a poor job of training, supporting and using these people in M&S development
- **Recognized the importance of using commercial products**
  - Example, need for automated development tools, data input and collection tools
  - But the trend is even stronger now (did not foresee breadth of technical breakthroughs, such as virtual immersion)

Some Shortfalls of SIMTECH 97

- **MORS community failed to adequately market the life cycle management recommendations and achieve their implementation**
  - Need to employ a proponent group to continually press key SIMTECH 2007 recommendations (ongoing briefings, staff interactions, ...)
- **SIMTECH 97 failed to project changes in the environment (end of Cold War, changes in technology, reduced funding and manpower, ...); not even considered**
  - Need to be more explicit of expected changes in SIMTECH 2007 (including RMA, commercial software evolution, pace of technology change, geopolitical, cultural, social, economic ...)
  - Need to document assumptions, cover the range of key uncertainties
- **Did not see extent that commercial companies would leverage DoD software investments, provide superior environments for future DoD work (spin off/spin on)**

Other Observations for the Future

- Does corporate management of DoD simulations need to be integrated (not by service)?
- Military acquisition process lacks flexibility for military simulation acquisition
  - Need to fix requirements generation process (need to consider what is doable, but then let technologists push the envelope)
- Future models need to be designed to accommodate requirements and technology changes
- Many models will be systems of models
  - Models need to be managed like C4ISR systems where continuous change is expected
- How far should we look ahead? — 10 years max

Report of the
Analyst Workbench Working Group

Participants

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Bob Smith
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MORS

SIMTECH97 Recommendations

- **Workbench architecture**
  - Enunciate architecture
  - Develop common specification language
  - Continue development of simulation languages
  - Develop ties between specification and simulation languages
  - Determine workbench security requirements
- **Define knowledge base for military simulations (Common iconography, OPLANs, algorithms, data standards, data bases, M&S, M&S VV&A documents, data VV&C documents, etc.)**
- **Development, management and use of repository**
- **Research in**
  - Spatial-temporal reasoning
  - M&S performance enhancements
    - Use of Parallelism
    - Special hardware
    - Object oriented: CPU architecture, software development

The WG defined an analyst workbench as an evolving architecture providing an integrated collection of standards, protocols and tools to enable analysts (including researchers and users) to build, understand, use and reuse simulations, using a range of approaches methodologies and languages. Three key needs were to be satisfied in order to develop and maintain such a capability. They included: an extensible, readable standard specification language for describing models; an extensible semantic dictionary to provide a sharable repository of models, submodels and data; and an architecture for integrating the tools and the repository by identifying components and specifying what must be standardized.

The WG identified five broad technology initiatives that should be undertaken as a foundation for the analyst workbench. These were: (1) develop the architecture (e.g., enunciate the architecture, develop a common specification language, continue development of simulation languages, develop ties between specification and simulation languages, determine workbench security requirements); (2) assemble the knowledge base for military simulation (e.g., common iconography, operational plans); (3) perform research in spatial-temporal reasoning; (4) perform research to achieve key performance enhancements (e.g., parallelism, object-oriented CPU architecture); and, (5) assemble repository elements (e.g., survey tools, find/prioritize software).

The WG further recommended that the community should monitor but not fund efforts in voice recognition, graphics or natural languages, since it believed that adequate work was in progress in the commercial sector.

What Did SIMTECH97 Do Well?

- **Identified need for**
  - Common workbench infrastructure, standards and tools
  - Knowledge base for military simulations
  - Development, management and use of an M&S repository system
  - Workbench security requirements
  - Research in object-oriented development
  - Research into spatial-temporal reasoning

The WG did a good job in identifying the main components necessary to support an analyst workbench. First was the common workstation infrastructure, standards and tools that would provide the basis for information exchange, interoperability, portability, reuse of M&S components, etc. Next, the objects and products to be used in the workbench needed to be identified and made available in a knowledge base for military simulations. These included: standards for data, symbols, icons, nomenclature, protocols; M&S and their components; databases; battlefield functions; operational plans; tools/toolkits; etc. Next was the repository system that registered, managed, searched, validated and in general made available the knowledge base products.

The WG realized that a major issue would be the security classification of the workbench which preferably would be multilevel but would at least need to be able to operate at different system high levels for different uses. Even more important was support for knowledge base products at different security levels and how the analyst could bring them together on the workbench to address the problem at hand. Practical solutions to the security problems are still needed.

Lastly research continues in two areas identified in 1987: object-oriented development and spatial-temporal reasoning. The 1987 focus was primarily on object-oriented CPU architecture whereas the focus in 1997 is on object-oriented software life cycle development (e.g., the Unified Modeling Language (UML)), object-oriented information modeling (e.g., IDEF1X97), object-oriented distributed systems (e.g, CORBA), all of which are critical to M&S. The two major new DoD modeling efforts, JWARS and JSIMS, are using object-oriented software approaches for design and implementation.

The research in spatial-temporal reasoning is still critical to M&S and has not moved as quickly as was anticipated in 1987. Recent ACTD and ATD efforts have been addressing the rapid provision of terrain data on demand which can serve as a basis for advances in spatial-temporal reasoning.

Type I Errors

- **Failure to foresee:**
  - Major technology advances
    - Rapid advances in chips, computers, memories, workstations, desktop computing, laptops, networks, communications
    - Development of internet and web, Java language, sharing of IT products
    - Development of collaborative software
  - Cold War:Ending resulting in reduced resources for analysis
  - Training: Capturing the playing field and M&S resources and raising the demand for interoperable M&S and development of DIS and HLA
  - Advances in standards: C4ISR community emphasis on interoperability of information systems resulting in TAFIM, TRM, JTA, DII DOE, data standards — all applicable to information infrastructure for analyst workbench
  - Languages: DoD rescinding the Ada mandate
  - Tools: Uncertainty and complexity becoming major analysis concerns and requiring new tools and approaches

As can be seen, the WG did not do a very good job in predicting what the environment would look like ten years hence. To begin with, the very rapid advances in computer and communications technologies were not anticipated as was the commercialization of the ARPANET into the Internet and the rapid expansion of the web and more recently the Java language. Much of the surprise has been due to the willingness of the commercial world to share information technology products even before the infrastructure to support quality, protection, intellectual rights, etc. has been developed and policy put in place.

The end of the cold war was not anticipated as was the reduction in DoD funding and the lack of resources for analysis at a time when the uses of analysis have been rapidly expanding. For example, DoD would like to reduce costs by using M&S as an integral part of the acquisition process as well as in training and exercises. Indeed the concept of distributed simulation which was fairly new with SIMNET technology in 1987 grew more rapidly than anticipated when the training community realized that live, virtual and constructive M&S could be used together in training exercises. SIMNET led to Distributed Interactive Simulation (DIS) which is based mainly on Protocol Data Unit (PDU) standards and that, in turn, has led to DMSO's definition of the High Level Architecture (HLA) that supports simulations interacting together as a federation. HLA includes rules, specification of a Run Time Infrastructure (RTI), the Application Programming Interface (API) specifications that M&S need to interface with the RTI, the information about the federates used by the RTI during runtime that is captured in a Federation Object Model (FOM).

Another unanticipated happening was the massive push in the C4ISR community to really tackle the lack of interoperability among C4ISR systems and more recently C4ISR systems, weapon systems, sustaining base systems and M&S. The Joint Technical Architecture (JTA) describes the standards necessary for IT systems to interoperate in several areas: processing standards, transfer standards, information modeling and message standards, Human Computer Interface (HCI) standards and security standards. The use of common software to form the basic infrastructure for a C4ISR workstation platform that is interoperable, portable, scalable is defined by the Defense Information Infrastructure (DII) Common Operating Environment (COE).

The 1987 WG did not anticipate, but did hope, that DoD would rescind the Ada language mandate.

Lastly, the WG felt that the 1987 WG was lacking in not paying more attention to the analytic need to address uncertainty and complexity in military simulations.

Type II Errors

- **Wrongly predicted a need for M&S special purpose hardware/software architectures and parallel architectures**

During the 1980s there was much R&D activity focused on parallel architectures and special purpose architectures to achieve performance improvements in M&S. Parallelism at the fine grained level within processors has overwhelmed the coarse grained parallelism that was thought to be so important when it was predicted that the industry would be bumping into technology limits. Within a few years we will have 1GHz processors with even more pipelining and superscalar pipelines, SIMD, etc. built in. So parallelism turned out to be more useful for distribution than for performance reasons.

The rapid and continuing increase in performance of "standard" commercial chips, CPUs, graphics engines, workstations along with reduction in size and cost makes special purpose solutions too costly and unnecessary. The use of COTS IT will yield increasing performance gain through evolutionary product development with business incentives to be backward compatible.

Assessment of SIMTECH97
Moving into Today (1 of 4)

- **Workbench architecture infrastructure being addressed by DoD M&S Master Plan and the C4ISR community interoperability efforts**
- **M&S common specification language as a way to capture M&S functionality, being partially met by HLA SOM and FOM, VV&A documentation**
- **M&S implementation language need affected by DOD rescinding Ada mandate**
- **Knowledge base for military applications being worked on by M&S community**
- **Repository being addressed by DMSO establishment of MSRR**
- **OO: commercial developments and use in JWARS and JSIMS**
- **Spatial-temporal reasoning: environment EAs, continued research needed**
- **Areas not being sufficiently addressed: security; HCI for workbench; standards for data, symbology, iconology, nomenclature, battlefield functions, algorithms; authoritative sources for models; reuse of M&S components**

Workbench architecture infrastructure needs are currently being addressed by the M&S community through implementation of the DoD M&S Master Plan being carried out by the DMSO, services and agencies and by the C4ISR community's push toward interoperability of systems through the use of interface standards and specifications and common use of infrastructure products. DoD has mandated the use of the HLA, JTA, DII COE in all DoD information systems (including M&S systems). The DoD M&S Master Plan objectives include establishment of an M&S framework (HLA, Conceptual Models of the Mission Space (CMMS), data standards); authoritative representations for environment, systems and human behavior; and an infrastructure that includes M&S VV&A documentation and the MSRR — all of which are critical to the workbench architecture. The C4ISR community has developed the DoD Technical Architecture for Information Management (TAFIM) from which the Technical Reference Model (TRM) has been extensively used to understand the critical interface areas for interoperability among C4ISR platforms. The JTA is essentially a DoD-wide profile of consensus-based standards and specifications to enable interoperability among workstation platforms. The current DII COE specifies software products to support three platforms: Sun, HP, WINTEL and defines the APIs to common products to be shared across DoD agencies and services such as the Joint Mapping Toolkit. These DII COE software products are the infrastructure for the workbench. M&S domain specific software (such as the RTI) and tools will become a part of the shared M&S domain environment.

An M&S common specification language was recommended in 1987 as a way to capture M&S information and functionality so that an AI system could help an analyst find relevant M&S or M&S components for possible reuse. Though this hasn't happened, the Simulation Object Model (SOM) and the Federation Object Model (FOM) required by the HLA to capture information about the simulation or federation as to the objects to be shared, time management, etc. captures much of this information in a standard format that can be manipulated by software (such as the RTI). In addition, M&S VV&A documentation registered with the MSRR and accessed through it, contains descriptive information about the M&S, its purpose, scenarios it can support, previous uses, data and information sources, etc. The current WG is unaware of efforts to develop a general M&S specification language but there are some efforts in that direction in the software industry (e.g., UML) and a few specific simulation specification languages such as the Condition Specific Language (CSL). The Air Force JMASS program has also developed a language for specifying JMASS models. The WG suggests re-examining this need for 2007.

Assessment of SIMTECH97
Moving into Today (2 of 4)

- **Workbench architecture infrastructure being addressed by DoD M&S Master Plan and the C4ISR community interoperability efforts**
- **M&S common specification language as a way to capture M&S functionality, being partially met by HLA SOM and FOM, VV&A documentation**
- **M&S implementation language need affected by DOD rescinding Ada mandate**
- **Knowledge base for military applications being worked on by M&S community**
- **Repository being addressed by DMSO establishment of MSRR**
- **OO: commercial developments and use in JWARS and JSIMS**
- **Spatial-temporal reasoning: environment EAs, continued research needed**
- **Areas not being sufficiently addressed: security; HCI for workbench; standards for data, symbology, iconology, nomenclature, battlefield functions, algorithms; authoritative sources for models; reuse of M&S components**

The development of an M&S implementation language suggested in 1987 was largely a reaction against the DoD mandate that Ada be the only programming language used in DoD information systems. Recently, DoD has rescinded this mandate and the latest JTA Version 2.0 draft says "programming language selections should be made in the context of the system and software engineering factors that influence the overall life-cycle costs, risks, potential for interoperability." The WG noted that different domains have developed high level languages for specific purposes that are compilable into C or C++.

Assessment of SIMTECH97
Moving into Today (3 of 4)

- **Spatial-temporal reasoning: environment EAs, continued research needed**
- **Areas not being sufficiently addressed: security; HCI for workbench; standards for data, symbology, iconology, nomenclature, battlefield functions, algorithms; authoritative sources for models; reuse of M&S components**

The need for a knowledge base for military applications is being partially met by execution of the DoD M&S Master Plan that requires: authoritative representations for environment, systems and human behavior; authoritative data and model sources; Executive Agents (EA) for environment; workshops for human behavior models/standards; push for M&S data models and standards for Data Interchange Formats (DIFs); SOMs and FOMs; CMMS; and VV&A documentation guidelines. The Army M&S Office (AMSO) also has an effort to define standards including those for algorithms and battlefield functions. DISA is responsible for the DoD-wide data standardization effort. M&S data standards should be nominated and incorporated into the Defense Data Model and Data Dictionary to provide interoperable standards across C4ISR and M&S. More effort is needed to define the types of objects needed in the knowledge base, some means of standardizing them, and ways to register, validate, maintain, search for them.

The DMSO establishment of web-based MSRRs, one unclassified and one at the secret level, directly support the workbench need for a repository. DMSO also provides organizational support for managing the MSRRs and a joint working group to guide their development. The WG recognizes a need for a language in which to tailor agents to search for information products in the MSRR.

Relevant commercial activity exists in three Object-Oriented (OO) areas: OO software life cycle development (e.g., the UML), OO information modeling (e.g., IDEF1X97) and OO distributed systems (e.g, CORBA). Two major new DoD modeling efforts, JWARS and JSIMS, are using OO software approaches for design and implementation. The WG recognizes a need for a high level M&S object taxonomy to ensure some compatibility across OO M&S.

Assessment of SIMTECH97 Moving into Today (4 of 4)

- **Spatial-temporal reasoning: environment EAs, continued research needed**
- **Areas not being sufficiently addressed: security; HCI for workbench; standards for data, symbology, iconology, nomenclature, battlefield functions, algorithms; authoritative sources for models; reuse of M&S components**

In the area of spatial-temporal reasoning, the recent DoD vision calling for support for precision weapons and information dominance has led to new requirements for higher resolution elevation data and features. The National Image and Mapping Agency (NIMA) was formed from several separate DoD organizations and through ATDs and ACTDs is addressing needs for: high resolution terrain, terrain elevation and feature data on demand with timely delivery, support for handling temporary and long term battlefield changes in terrain ("dynamic terrain"), the use of commercial terrain products. DMSO has established Executive Agents for the environmental areas. The Army and DMSO are supporting the Synthetic Environment Data Representation and Interchange Specification (SEDRIS) to address sharing and reuse of environmental data among M&S. The intelligence community has continuing efforts to fuse and integrate data from multiple sources. Limited papers have been written that address temporal logic for M&S but much research still remains to be done in spatial-temporal reasoning.

Lastly areas that have not received sufficient attention are: security; Human Computer Interface (HCI) for the workbench; standards for data, symbology, iconology, nomenclature, battlefield functions, algorithms; authoritative sources for models; reuse of M&S components.

Recommendations (1 of 2)

- **Re-examine requirements for analyst workbench**
- **Re-examine need for general M&S specification language and/or implementation language**
- **Recommend defining areas that the M&S tools/capabilities should support, specifically: C4ISR, uncertainties, VV&A, extending range of OR and expert tools**
- **Recommend efforts in:**
  - Security solutions
  - HCI for workbench
  - Knowledge base for military applications
  - MSRR, including language to tailor agent for searching MSRR
  - Research in spatial-temporal reasoning
  - Common M&S OO taxonomy

The WG recommends much more attention be paid to the users of the workbench, their needs, workbench priorities with respect to providing support for various parts of the M&S life cycle. The WG needs to consider what analyses roles the workbench should support. Should the tools support development of M&S by software developers, and/or development of M&S by reusing components through a high level interface, perhaps interactively by decision makers or staffers? Should the workbench be designed for analysts who have OR type of expertise or should it also be made available to decision makers and/or staffers? If used by decision makers and/or staffers, then how can they be helped to understand the implications of their choices, how will they or should they perform VV&A.

The WG recommends that the needs for a common M&S specification language and one or more implementation languages be re-examined. The S1997 recommendation to develop an M&S specification language was primarily to enable software assistance to the analyst in finding the M&S, components, etc. that were relevant. The HLA requirement that each M&S have a SOM that defines specific M&S characteristics relevant to an HLA federation and for a federation to define a FOM to be used by the RTI partly answers the need recognized in 1987. M&S VV&A documentation will also provide textual information about the respective M&S including its purpose, scenarios, data, previous uses, etc. In addition, the WG recommends that an analytic object model be defined to extend the SOM to include additional types of M&S information specific to analysis.

The WG was unsure as to whether the software community at large has developed a generalized specification language, but believes the UML methodology may contain one. Several people were aware of specialized M&S specification languages, such as one for models participating in the AF JMASS program.

With respect to an M&S implementation language, the SIMTECH97 issue was that a common M&S implementation language would be more appropriate for M&S development than Ada which at that time was mandated by DoD. The Ada mandate was recently rescinded and so there may no longer be a need for a common M&S implementation language.

Recommendations (2 OF 2)

- **Re-examine requirements for analyst workbench**
- **Re-examine need for general M&S specification language and/or implementation language**
- **Recommend defining areas that the M&S tools/capabilities should support, specifically: C4ISR, uncertainties, VV&A, extending range of OR and expert tools**
- **Recommend efforts in:**
  - Security solutions
  - HCI for workbench
  - Knowledge base for military applications
  - MSRR, including language to tailor agent for searching MSRR
  - Research in spatial-temporal reasoning
  - Common M&S OO taxonomy

.The WG recommends more attention be paid to determine the areas that the workbench tools should support such as: C4ISR modeling which is inadequately done in most M&S and is especially necessary as the military continue to focus on information dominance; representation and handling of uncertainties and complexity; M&S of VV&A; and extending the range of OR and expert tools. The WG recommends continuing efforts in the areas of: security, HCI, knowledge base (including standards for data, symbology, iconology, nomenclature, battlefield functions, algorithms; authoritative representations for models); MSRR especially with respect to reuse of M&S components; research in spatial-temporal reasoning; and development of a common M&S OO taxonomy. The security area needs attention with respect to (1) a workbench alternative to multilevel if that is unobtainable, (2) attention to integrating information objects across classification levels, (3) handling a change in classification level due to aggregation of large amounts of information, (4) the need within the M&S community for DoD policy that supports and incentivizes sharing of M&S and data. The WG recognizes a need for a workbench HCI and style guide that would be compliant with the JTA but would be tailored to meet the specific needs of the M&S domain. The WG recommends continued development of the knowledge base and the MSRR capabilities to support reuse of M&S components and continued research on spatial-temporal reasoning. Lastly, WG recommends that the M&S community develop a high level common OO taxonomy to support the development of consistent and integrable object hierarchies across M&S.

Lessons Learned from SIMTECH97

- **SIMTECH97 didn't pay enough attention to predictions of future environment: perhaps get brief from futurist as common base for next workshop**
- **SIMTECH97 WG didn't address who the analyst is/are, the needs/requirements for the workbench, the workbench tools to a reasonable depth**
  - Need to have the "right" people participating in the WG (people actively involved in analysis and the development/use of tools) to answer these questions
- **SIMTECH97 WG didn't pay sufficient attention to modeling and analysis needs such as dealing with uncertainty, VV&A, etc. but focused on information technology such as software and distributed system issues**

The WG felt that SIMTECH97 didn't pay sufficient attention to predicting the future environment and suggests that the next workshop may want to invite one or more futurists to provide input for developing a consensual view of the future environment.

As was mentioned on the previous chart, the WG felt that the SIMTECH97 WG did not adequately address who the analysts were, their needs and requirements and the tools that could satisfy their needs and requirements. The WG recommends that the WG at the next workshop be composed primarily of active practitioners not M&S managers in order to answer these questions.

Lastly, the WG felt that the SIMTECH97 WG over emphasized technology and didn't pay enough attention to M&S needs such as addressing uncertainty, VV&A knowledge base, etc.

Other Findings and Recommendations

- **Address whether tool developers and users have to be software engineers to build simulations and, if so, then how do they maintain connection to the OR/analysis community to understand and meet their needs?**
- **Re-examine the future roles involved in simulation development, analysis and use (e.g., decision maker, staffer, analyst, simulation developer, simulation modifier).**

The WG was concerned with whether software development and OR tool development/usage have both become so technology intensive that it may not be possible to find people with both skills to develop M&S. If that is so, then attention needs to be paid as to how M&S will be developed so they adequately address OR concerns.

A related issue, is for the next workshop to re-examine the roles involved in M&S development and in its use for analysis. First, if M&S development needs to be done by software engineers then how well will they be responsive to OR needs. Secondly, if there are high level tools that make it easy for analysts and/or decision makers and staffers to modify M&S or compose a new M&S from reusable components, what kinds of help do they need in understanding tradeoffs, performing VV&A, etc. Include consideration of decision makers having to make time critical decisions such as for COA analysis. Also take into consideration the fact that in the future there might not be such a clean break between M&S for analysis (e.g., JWARS) and M&S for training (e.g., JSIMS). There may be more and more of a need to analyze training exercises and perhaps the development of new tools to support such analyses.

Report of the Soft Factors Working Group

The Soft Factors Working Group opened with a brief retrospective of the work of SIMTECH 97 and then the chair laid out the tasks the group was responsible for addressing for the afternoon briefing session. The group was charged with reviewing the analysis and recommendations of the Soft Factors Working Group at SIMTECH 97. The group was to assess what its SIMTECH 97 counterparts did right, what was misidentified and what was omitted from the analysis. Based on this assessment, the group was to draw lessons learned and propose a series of recommendations to guide future efforts in soft factors.

Participants (1 of 2)

Dick Hayes, Chair
Lashon Booker, Co-Chair

MAJ Jack Jackson
John Shepherd
Doug Kupersmith
Clayton Thomas, FS
Charlie Leake
Peter Campbell
Brian Smith

Following the background review, the members of the group introduced themselves and made their initial comments on the SIMTECH 97 work. The participants were concerned that soft factors as a group were not well defined, that the enhancements provided by soft factors were not tangible and thus their utility is hard to defend to sponsors, there was no institutional advocate for soft factors and it was commonly assumed that soft factors were the purview of the services. Participants were also concerned that the modeling of soft factors was characterized by the substitution of goals for standards in dealing with seemingly insolvable problems. Additional points included the lack of effort to record human reactions and to develop data to support soft factors and the hazards of using incomplete or inappropriate soft factors or soft factor data.

The group moved into a general discussion, based in part by their initial comments, and in part on the comments by the chair. It was stated that the lack of institutional support has made it difficult for objectives and standards to be developed because they are not necessarily based in a specific requirement. Though requirements or standards for soft factors could be drawn from existing directives in support of JV2010, it was important to recognize the tradeoffs between descriptive versus prescriptive modeling and to distinguish broad goals from specific solutions.

One of the difficulties in soft factors is the lack of information on group or social interactions as opposed to individual psychology. If command and staff interactions are taken as social processes, then it enters the realm of the sociologists and anthropologists. Such disparities point to the fact that the science behind soft factors is weak. If the science is weak, the engineering is weak and consequently the best modeling is a relatively poor tool. As the sciences supporting soft factor elements tend to produce probabilities and distributions rather than single point data, they are fraught with uncertainty. The result is that movement within the distribution tends to aggregate uncertainty within and between models. Unfortunately, the cumulative uncertainty may overwhelm the knowledge produced by modeling.

The chair reinforced the above points by examining the differences between simple and complex decisions. As simple decisions tend to gain parties, they slow down but maintain the same level of quality. However, in the case of complex decisions, the addition of parties also slows the process, but does improve the quality of the decisions. While the rule has an important consequence for modeling decision making, it exists at a level of generality which makes it difficult to adequately represent.

Participants (2 of 2)

Dick Hayes, Chair
Lashon Booker, Co-Chair

MAJ Jack Jackson
John Shepherd
Doug Kupersmith
Clayton Thomas, FS
Charlie Leake
Peter Campbell
Brian Smith

Following that thread in the discussion, a participant pointed out that part of the resolution to this problem was to decide on what science (sociology, anthropology, psychology, etc.) was to be used, select an area of soft factors to focus on, determine the kinds of experiments that were supported by the relevant methodologies, and then choose among the sub-disciplines for further analysis and data generation for modeling.

It will be important to identify problems, which are currently of concern, that have been allowed to lag. The identification of these problems can help to focus resources and begin to develop some institutional support for soft factors.

Experimentation is a difficult area to push forward. The battle labs and other simulation infrastructure do very little true experimentation. The tendency is to provide systems to potential users and then observe them using the system. The lack of structured experimentation is hampering the generation of reliable soft factors data. The number of instrumented ranges is declining and facilities for structured data collection are being reduced.

Two participants pointed out that the collection of data is fine, but that which has been collected is difficult to access and the existence of much of the research is not commonly known. A clearinghouse of soft factor data and studies, plus a place for interaction such as a chat room would be useful. Another pointed out that the Army Modeling and Simulation Office has an archive of studies which may be useful.

It was pointed out that many similar recommendations have been made in the past, but have not been acted upon. This applied to the range of discussion, not just the clearinghouse and chat room. The concern was that without some institutional support or sponsorship, the recommendations developed by the group would not receive supporting actions.

SIMTECH 97 Recommendations (1 of 2)

- **Establish an Operational Performance Measurement Program for soft factors**
- **Report on what is now being done/not done and prioritization of needs**
- **Adopt an experimental paradigm**
  - Maximize data validity
  - Apply quasi-experimental designs
- **Create a data registry**

SIMTECH 97 Recommendations (2 of 2)

- Build on existing tools for evaluating quality of command and control
- Require transfer plans for simulations developed for multiple users
- Focus community attention on soft factors
- Broaden behavioral science base: expertise and education
- Emphasize group and organizational behavior

Assessment of SIMTECH 97

- **What did it do well?**
  - Causal factors, modeling issues and soft effects identified correctly
  - State of the art assessed correctly
- **What did it not do well?**
  - Understated the influence of information on the battlefield
  - Incomplete specification of the solution space

The group determined that the causal factors, modeling issues and soft effects identified at SIMTECH 97 were still appropriate and the lists were complete. The discussion focused around the ability to accurately model the soft effects and whether the definitions of the soft effects translated to traditional modeling terms, notably the idea of disruption. They also felt that the SIMTECH 97 work continued to accurately reflect the state of the art. There was some concern over the slow pace of advancement in the areas of cognitive processes and human factors, especially at the group level.

In addressing the shortcomings of SIMTECH 97, the group felt that the influence of information on the battlefield was understated. The most significant shortcoming was understating the impact of the increase in speed, both in moving information to the battlefield and processing in general. The group also felt that the solution space was insufficiently specified, thus there was insufficient structure to begin a systematic inclusion of soft factors.

Lessons Learned

- **Soft factors over aggregated; did not penetrate the problem.**
- **Failure to forecast the speed of improvement in information technologies**
- **Failure to foresee the importance of information warfare**
- **Failure to recognize the importance of context**
- **Failure to identify institutions to support and to carry through recommendations**

The group felt that soft factors were generally over aggregated, making it difficult to drill down to the level of detail that would have a noticeable impact on modeling. Aggregation also makes it difficult to show sponsors and supporting institutions the value added from modeling soft factors. The group reinforced its belief that the failure of SIMTECH 97 to address improvements in information technologies was also a lesson learned, and went on to include the failure to foresee the impact of issues loosely defined as information warfare. Though deception and false images could be simulated and included in models, more attention needed to be paid to the defeat of sensors and reliance on automated decisions.

The group felt that importance needed to be placed on putting soft factors into context. The value of soft factors is enhanced by putting them into a useful context. Context would also aid the structuring of data collection and experimentation.

Finally, the group recognized the importance of identifying institutions to support and carry through with the recommendations. The discussion focused on the apparent lack of specific requirements for soft factors as preventing institutions from stepping forward, even those who have charter responsibility. The soft factor problem may be so difficult that developing or identifying sponsors may be a continuing problem.

Current Recommendations (1 of 2)

- **Need to anchor to a clear articulation of requirements; motivate ownership and sponsorship**
- **Need to prioritize the soft factors and how they effect the solution space(s)**
- **Soft factors may require different approaches and techniques**
  - Identify useful knowledge and build on it (cognitive science, stochastic representation, etc.)
  - Incorporate learning algorithms
  - Draw from dynamic game theory

Soft factors need to be anchored to clearly articulated requirements so as to develop a sense of institutional ownership. The current substitution of goals for standards is hindering that process.

Though SIMTECH 97 made a complete list of factors, it is important to move forward with a prioritization of those factors. The impact of soft factors on the definition of a solution space needs to be determined, which will further enhance their utility and the development of institutional ownership.

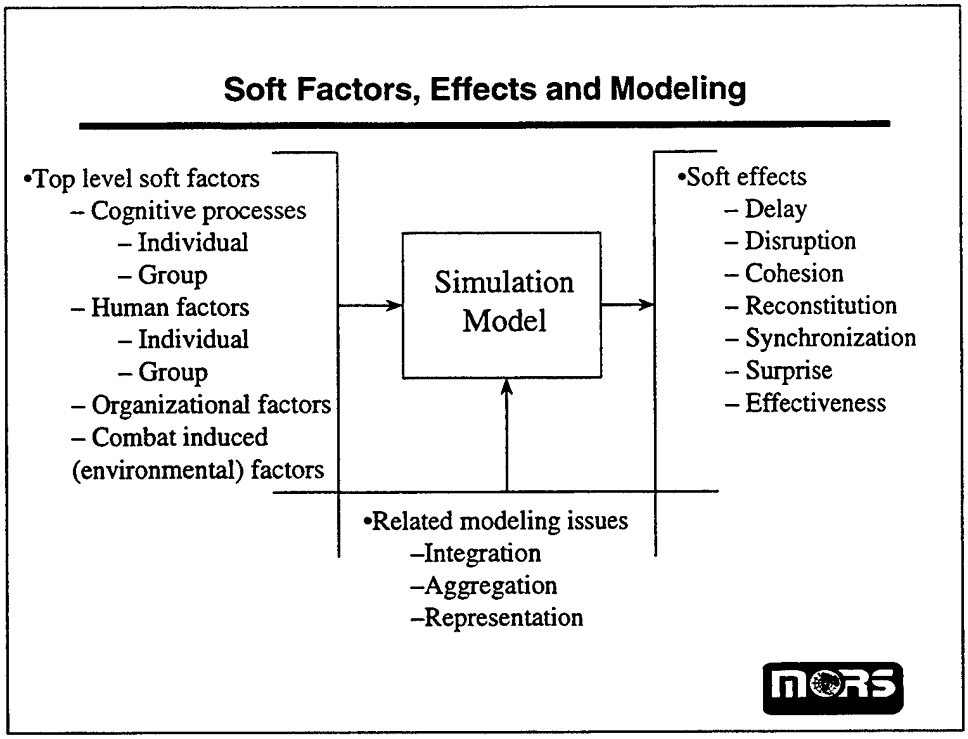
The individual soft factors will require a separate approach in terms of identifying available knowledge and developing strategies and efforts to build on that knowledge base. Research and development of learning algorithms will also require separate approaches so that the algorithms can better address the subtleties of each factor, especially in the case of aggregated factors. Separate approaches and techniques may also be useful in the case of dynamic game theory.

Current Recommendations (2 of 2)

- **Use an experimental paradigm**
  - Control most factors
  - Manipulate selected issues
  - Accumulate data and parameters
- **Create an ongoing working group**
  - Build a clearinghouse on the Web and provide contractor support;
  - include a chat room, interacting with DMSO and other relevant organizations

The group recommended the use of an experimental paradigm to provide control for most factors, to manipulate selected issues so as to determine their impact on causal relationships and to aid in the accumulation of data and the development of parameters. The experimental paradigm would begin to lend structure to the process of including soft factors and is an important primary step.

Finally, the group decided that an ongoing working group should be created and that in support of that working group, a clearinghouse of data and studies should be established on the web. The clearinghouse should be supported by contractors to maintain currency and usability. As an adjunct, the clearinghouse would also have a chat room to aid the interaction among modelers, DMSO and other relevant organizations.



The last slide depicts the basic relationship between soft factors, related modeling issues and soft effects being fed through a simulation model. The slide shows that aggregated soft factors, when filtered through a simulation model and combined with other basic modeling issues, produces a series of soft effects which can be incorporated into other levels of modeling. The slide lists the soft factors identified in SIMTECH 97, which the SIMTECH 07 participants endorsed as being correct and complete.

Report of the
Data Working Group

Participants

Phil Dickinson, Co-Chair
Carl Russell, Co-Chair

Phil Abold
Michael Bailey
Phil Dickinson
John Hughes
Gary Jones
LTC Mike McGinnis
Lana McGlynn
Carl Russell
Cy Staniec
Dave Thomen

SIMTECH '97 Revisited - DWG

- "Without Data we are nothing" La Berge '87
- SIMTECH 97 Data Group developed two viewpoints
  - The ability to capture quality data and make it available to modelers was severely limited
  - The environment to generate good representative data for many weapons/environments/scenarios is severely limited
- A top level review today seems to indicate that:
  - The DMSO-led effort is cataloging authoritative data sources
  - There is no ongoing effort to build a DoD-wide integrated database
  - In recent years major OTs are less prevalent/less instrumented and therefore less hard data is available — and the world has changed
  - No effective transducer for data from targets of opportunity (AWEs and exercises)

DWG - Type I Errors, Pd

- **Data...will not change radically in 89 - 97 window**
  - Clearly the "outbreak of peace" demands different sorts of data and modeling.
  - What are the current needs?
- **Overt structure that links all members of data/modeling team**
  - No such DoD-wide structure exists
    (but implemented within major programs)
  - Failed to recognize the internet as the logical vehicle to achieve a networked community

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DWG - Type II Errors, Pfa

- **Characterize EM environment**
  - Information Warfare is the current buzz word, but little/no progress toward characterizing the EM environment
  - EM was too restrictive to characterize environmental effects
- **Missed Simulation Based Acquisition (SBA)**
  - Changes the fundamental relationship between M&S and field data collection — instead of providing data to load models, field tests will be used more to validate models

Assessment of SIMTECH '97 Data WG

- **Complex models...Demand disciplined process of definition, design, implementation and documentation — which is not compatible with an *ad hoc* approach**
  - They demand rigorous systems engineering
- **Moving from monolithic models to distributed federated models demands increased system engineering**
  - Selected flag ship models are working the problem well — but this is not the common approach

Recommendations

- **Data important**
  - Data sources drying up
    - Few dedicated experiments to generate data
    - Fewer instrumented OTs
    - Data outsourced/vendor generated (ownership)
  - Incomplete process to acquire and manage available data
    - Inadequate data requirements process
    - No disciplined processes to harvest useful data from AWEs and exercises
- **This is a problem that needs to be addressed by the M&S Working Group (chaired by DMSO)**

Other Findings and Recommendations (1 of 2)

- **Need Godfather to make institutional things happen**
  - Need to create integrated data process across DoD to support SBA
  - Energize the EXSIM to focus the OSD leadership on the need for robust data
- **Modify TOR to include the individuals and organizations who generate the data in defining the solution (AWEs, FTXs etc.)**

Other Findings and Recommendations (2 of 2)

- **Where are the "experimenters" who generate the data to validate models?**
  - Look for innovative techniques to replace dedicated experiments
- **Would be useful to include the decision makers in the process — the people who spend money based on M&S results — not just the proponents who "like M&S"**

Lessons Learned from SIMTECH '97

- **S97 DWG focus was too narrow**
  - Composed mostly of data-generating people
  - Need producers and consumers
  - Don't focus WG composition too narrowly
- **Complexity of the data requirements has increased**
  - Additional data sources
  - Multiple mission requirements
  - International data requirements
  - State Department in charge of peace-keeping team
- **The data process posited in S97 has not materialized**
  - Bigger problem today

MORS

Lessons Learned

- **Watershed events occurred since S97**
  - Warfighting
    - Wall came down
    - Peacemaking, Operations Other Than War
    - Desert Storm
    - NBC
  - Technology
    - Distributed processing
    - Computer hardware
    - Internet
- **Even with this turbulence**
  – change has taken place majestically

Terms of Reference
Military Operations Research Society (MORS)
Simulation Technology 2007 (SIMTECH 2007)

Background

In 1987, MORS was approached by representatives of the Army, Air Force, and Joint Staff to assess the appropriate direction for the sponsors to take in military simulation technology, over the following decade, in support of the analysis community. First, the participants were to identify and prioritize deficiencies in military simulation. Based on an understanding of these deficiencies, appropriate technologies were to be identified and assessed that have the potential to ameliorate these deficiencies in the near- and mid-term (out to 1997). Finally, a set of recommended follow-on actions were to be proposed to implement the workshop's findings and recommendation.

In order to satisfy those objectives, three workshops were held. These culminated with a set of recommended actions to ameliorate shortfalls in four key areas: life cycle management, analyst workbench, "soft" factors, and data.

Current, related DoD programs to address simulation deficiencies are underway in the areas of analysis (e.g., the Joint Analysis Model Improvement Program (JAMIP)), training (e.g., Joint Simulation System (JSIMS)), and acquisition (e.g., Simulation Based Acquisition).

Goals and Objectives

The overarching goal of SIMTECH 2007 is to promote more effective dialogue between the users of modeling and simulation (M&S) and the M&S technology community. Consistent with that goal, the objectives of SIMTECH 2007 are to:

(1) Review and assess the findings and recommendations that were made by the participants at SIMTECH 97. This will include an assessment of the accuracy with which the participants were able to identify and characterize deficiencies and major M&S trends and issues over the past decade, the appropriateness of the recommendations that the participants made, and the extent to which the recommendations were implemented.

(2) After consideration of the lessons learned from the retrospective assessment, the participants will identify and prioritize the needs of the users of military M&S and assess the probable evolution of M&S technology over the next decade. Based on an understanding of these prioritized needs and technology trends, appropriate technologies will be identified and assessed that have the potential to ameliorate identified deficiencies looking out to the year 2007. The participants will identify a set of recommendations to address these perceived deficiencies.

Scope

SIMTECH 2007 will consider M&S in support of analysis, training, and acquisition. This represents an expansion of the scope of SIMTECH 97 which was restricted to the support of analysis. Technologies will be considered in the near-term (e.g., 2002 timeframe) and longer-term (i.e., out to 2007). The activity also may consider issues that relate to technology transfer into organizations (e.g., organizational mission and structure, training, facilities).

Activities

The objectives of SIMTECH 2007 will be achieved by convening two workshops.

- **Workshop I**

Workshop I will be held in Northern Virginia in December 1997. As a context for the workshop, a read-ahead package will be distributed that includes, inter alia, the final products that were developed in SIMTECH 97. Extensive use will be made of the Internet to identify and make accessible relevant information.

The agenda for the three day unclassified workshop will be as follows. The workshop will begin on the morning of Day 1 with a plenary session that includes a presentation on the purpose and structure of the workshop, a keynote address by Ed Brady that reviews the key findings and recommendations that emerged from SIMTECH 97, and a presentation by an expert in modeling and simulation (M&S) that reviews the key events in the area of M&S that have occurred between the years 1987 and 1997. The participants will then breakout into the four groups that were employed in SIMTECH 97: life cycle management, analyst workbench, "soft" factors, and data. To the extent feasible, these breakout groups will be co-chaired by the individuals who chaired the original groups in SIMTECH 97. These groups will conduct deliberations to address the first set of objectives identified above. In addition, a Synthesis Group will be established to identify and characterize observations that cut across the deliberations of all the breakout groups. In the morning of Day 2, these groups will report out on the results of their retrospective assessments.

Immediately after the retrospective working group brief outs on Day 2, a panel of experts will address the latest initiatives, objectives, and priorities of using M&S in support of analysis, training, and acquisition. These experts will be the chairs of the EXCIMS councils: Jim Johnson and Vince Roske, Analysis; Pat Sanders, Acquisition, Lou Finch and the Director, J7, Joint Staff, Training. This panel will provide a context for the subsequent breakout groups by providing a vision of M&S technology and requirements out to 2007.

After the panel, the participants will breakout into two clusters. Cluster A will identify and prioritize the functional needs for M&S in the functional areas of analysis,

training, and acquisition[1], using the information and guidance given to them by the panel as a basis for addressing the needs beyond the currently projected initiatives. Cluster B will perform a technology assessment of the likely evolution of M&S technology (civilian and DoD) over the next decade. At the discretion of the Technology Cluster leadership, the cluster may be divided into several subgroups (e.g., information technology; representation of environment; representation of human behavior; "new sciences").

The leaders of the breakout groups will brief out their results on the afternoon of Day 3. The workshop will conclude with a presentation by the Synthesis Group that provides a synoptic overview of the proceedings. The leaders of the breakout groups will remain until noon of the following day to annotate the vugraphs that they used to brief out their results.

• Workshop II

Workshop II will be held in the Spring of 1998. As context for Workshop II, a read ahead package will be assembled and distributed prior to the workshop that includes, inter alia, the annotated briefings that were developed in Workshop I. Again, the Internet will be used as the primary mechanism for disseminating information.

The Agenda for the three day workshop will be as follows. The workshop will begin on the morning of Day 1 with a Plenary session that includes a presentation on the purpose and structure of Workshop II and a summary of the major results from Workshop I. The participants will then breakout into the functional work groups employed in Workshop I with the original groups augmented with appropriate experts from the technology cluster. During the course of Workshop II, the augmented functional breakout groups will:

- Review and validate the functional needs identified and prioritized in Workshop I;
- Translate the prioritized functional needs into technical needs;
- Identify potential military simulation technology shortfalls by comparing the technical needs to the results of the M&S trends analyses from Workshop I;
- Prioritize these shortfalls and recommend actions to ameliorate them.

On the afternoon of Day 3, the leaders of the breakout groups will brief out their major findings and recommendations. The workshop will conclude with a presentation by the Synthesis Group which will identify and discuss similarities and differences among the findings and recommendations of the breakout groups. The breakout group leadership will remain until noon of the following day to complete the annotation of their vugraphs.

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[1] During the course of the Workshop, it may prove desirable to divide the analysis group into two subgroups: analysis in support of operations (e.g., course of action analysis and mission rehearsal and assessment) and analysis in support of high level decision making (e.g., force structure and force mix analyses; support to planning, programming, and budgeting activities).

Products

The primary product of the workshops will be an annotated briefing booklet that includes an overview of the workshops and individual chapters documenting the deliberations of the working groups. In addition, an overview white paper will be prepared that is suitable for publishing in Phalanx and a briefing will be prepared for the MORS Sponsors and the 66th MORSS.

Membership

The workshop will be organized by a committee that consists of Stuart Starr (chair), Bob Orlov (co-chair), Howard Carpenter, Denis Clements, Bob Statz, and Ken Konwin (MORS Workshop Advisor). The chairs will control the attendance so that it is approximately 120 per workshop. Attendees will be sought from both the SIMTECH 97 workshops, for continuity, and new participants, to introduce fresh perspectives. These new participants will be drawn from council functional working group members, appropriate MORS working groups, and experts from advanced M&S fields outside of the usual DoD operations research and related disciplines.

Chairs for the first breakout session of Workshop I will include: Bruce Bennett and Bob Statz (Life Cycle Management); Iris Kameny and John Gilmer (Analyst Workbench); Dick Hayes and Lashon Booker ("Soft" Factors); and Phil Dickinson and Carl Russell (Data). Chairs for the second breakout session of Workshop I remain to be determined but candidates include Cy Staniec/Hank Dubin/Russ Richards (Analysis); LTC Coble/Zach Furness (Training); and Dick Helmuth/Gary Jones (Acquisition). Candidates for leadership of the Technology Assessment Cluster include Denis Clements, and Dell Lunceford. The Synthesis Group will include Paul Davis, Clayton Thomas, and Vern Bettencourt.

In Workshop II the chairs for the functional breakout groups will be retained from the comparable breakout groups from Workshop I, to the extent feasible.

Schedule and Fees

Workshop I will be held in McLean, VA, at GRCI during the third week of December (16 - 19 December). Workshop II will be held in McLean, VA, at Booz, Allen & Hamilton (BAH) during the first week of March 1998 (4 - 6 March). The fee is anticipated to be $175 for federal government employees and $350 for all others, for each workshop, with a $50 reduction if the participant attends both workshops. This fee structure will be part of the management plan developed by the MORS Office, the MORS Workshop Advisor, and the Workshop Co-chairs.

A selected set of major milestones is as follows:

1 Oct	Complete identification, selection, and gaining acceptance of co-chairs for breakout groups of Workshops I and II
15 Oct	Send out first round of invitations to Workshop I
20 Oct	Develop and disseminate product outline for Workshop I
3 Nov	Begin to populate the read ahead Internet page for the workshop
19 Dec	Generate rough draft of Executive Summary; generate preliminary annotated vugraphs for each working group
8 Jan	Send out invitations to Workshop II
20 Jan	Submit draft of Executive Summary and annotated vugraphs for Workshop I to the MORS Office; if deemed appropriate, generate draft article to *PHALANX* editor
2 Feb	Disseminate draft materials from Workshop I and other read ahead material to participants in Workshop II
6 March	Generate rough draft of complete Executive Summary (encompassing Workshops I and II), along with preliminary annotated vugraphs for the working groups in Workshop II
6 April	Submit article to Phalanx editor; submit draft of total Executive Summary and annotated vugraphs for both Workshops to MORS Office
6 May	Receive comments on draft from key personnel; brief Sponsors; incorporate Sponsor feedback in executive summary; post approved Executive Summary on web site
June	Brief out the results of SIMTECH 2007 at 66th MORSS
6 August	Submit smooth report to printer
7 Sept	Publish and distribute report

SIMTECH 2007

Workshop Organizers

Position	Name	Affiliation
Chair	Stuart Starr, FS	MITRE
Co-chairs	Howard Carpenter Denis Clements Lana McGlynn Bob Orlov Bob Statz	MITRE GRCI DAMO, USA J-8, JS BAH
MORS "Bulldog"	Col "Crash" Konwin	DMSO

Working Group Leadership

Retrospective 	Life Cycle Management	Bruce Bennett, RAND Bob Statz, BAH
	Analyst Workbench	Iris Kameny, RAND John Gilmer, Wilkes University
	"Soft" Factors	Dick Hayes, EBR Lashon Booker, MITRE
	Data	Phil Dickinson, Consultant Carl Russell, JNTF
Looking Forward 	Analysis	Cy Staniec, Logicon Hank Dubin, OPTEC Russ Richards, MITRE Mark Youngren, MITRE
	Acquisition	Gary Jones, DARPA Dick Helmuth, SAIC Annie Patenaude, SAIC Dell Lunceford, DARPA
	Education and Training	Phil Abold, A&B Technology Zach Furness, MITRE Julia Loughran, Thoughtlink
	Technology Assessments	Dell Lunceford, DARPA Denis Clements, GRCI Julia Loughran, Thoughtlink
	Synthesis	Paul Davis, RAND Clayton Thomas, FS, USAF

Participants in SIMTECH 2007 Workshop I

Phil Abold	AB Technologies
Jesse Aronson	SAIC
Michael Bailey	MCCDC
Bruce Bennett	RAND
Lashon Booker	MITRE
Peter Campbell	Argonne National Lab
Howard Carpenter	MITRE
Denis Clements	GRCI
Gerald E. Cooper	UFSA CAA
CAPT Robert Danberg	COMTRAPAC
CAPT Lee Dick	OPNAV
Phil Dickinson	Consultant
Norman Eagleston	Sun Microsystems
Gary Engel	Boeing
Dean Free	Navy
Robin Frost	OSD
Charles Z. Furness	MITRE
John Gilmer	Wilkes University
Priscilla Glasow	MITRE
Dick Hayes	Evidence Based Research, Inc.
Richard Helmuth	SAIC
John Hughes	MITRE
Susan Iwanski	Northrup Grumman
MAJ Jack Jackson	TRAC - Monterey
Gary Jones	ARPA
Iris Kameny	RAND
Gary Klein	MITRE
COL Crash Konwin	DMSO
Doug Kupersmith	S3I
Charlie Leake	JWARS
Dell Lunceford	DARPA
Joe Manzo	MITRE
Richard Maruyama	AMSO
LTC Mike McGinnis	TRAC Monterey
Lana McGlynn	AMSO
Richard Modjeski	Consultant
Richard Nance	Virginia Tech
Steve Olson	Raytheon
Robert Orlov	JS, J8
Ernie Page	The MITRE Corporation
Mel Parish	TRACWSMR
Annie Patenaude	DUSA
F. Russ Richards	MITRE
Carl Russell	JNTF/SE

Bob Sheldon	S31
John Sheperd	USACAA
Brian Smith	Evidence Based Research, Inc.
Bob Smith	Raytheon
Marcy Stahl	ThoughtLink, Inc.
Cy Staniec	Logicon
Bob Statz	BAH
Scott Swinsick	The Boeing Company
Clay Thomas	HQUSAF AFSAA
Dave Thomen	SAIC

Participants in SIMTECH 2007 Workshop II

Phillip L. Abold	AB Technologies, Inc.
Thomas L. Allen	IDA
Dennis R. Baer	Logicon
Steven C. Bankes	RAND
Natalie S. Addison	MORS
Jesse Aronson	SAIC
Thomas J. Baker	Logicon
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SIMTECH 2007 Acronyms

ACTD	Advanced Concept Technology Demonstrations
ACOM	US Atlantic Command
ADL	Advanced Distributed Learning
ADS	Advanced Distributed Simulation
AI	Artificial Intelligence
AMSO	Army Modeling and Simulation Office
API	Application Programming Interface
ARPANET	[Defense] Advanced Research Projects Agency Network
ATD	Advanced Technology Demonstration
ATM	Asynchronous Transfer Mode
AWE	Army Warfighting Experiments
BAH	Booz-Allen Hamilton
C2	Command & Control
C3I	Command, Control, Communications and Intelligence
C4I	Command, Control, Communications, Computers and Intelligence
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance
CAD	Computer Aided Design
CAM	Computer Aided Manufacturing
CGF	Computer Generated Force
CINC	Commander-in-Chief
CMMS	Conceptual Models of Mission Space
COA	Course of Action
COE	Common Operating Environment
CONUS	Continental United States
CORBA	Common Object Request broker Architecture
COTS	Commercial Off the Shelf
CPU	Central Processing Unit
CSL	Condition Specific Languages
DARPA	Defense Advanced Research Projects Agency
DDR&E	Director, Defense Research and Engineering
DEVS	Simulation language from Univ. of Arizona
DIF	Data Interchange Format
DII	Defense Information Infrastructure
DIS	Distributed Interactive Simulation
DISA	Defense Information Systems Agency
DL	Distance Learning

DMSO	Defense Modeling and Simulation Office
DoD	Department of Defense
DoE	Department of Energy
DSB	Defense Science Board
DTSE&E	Director, Test, systems Engineering, and Evaluation
DUSD	Deputy Under Secretary of Defense
DWG	Data Working Group
E&T	Education and Training
EA	Executive Agents
EBR	Evidence Based Research
EM	Electromagnetic
EXCIMS	Executive Council on Modeling and Simulation
Flames	A Simulation Development Environment
FOM	Federation Object Model
FTX	Field Training Exercise
GOTS	Government Off the Shelf
GPS	Global Positioning System
GRCI	GRCI International, Inc.
HBR	Human Behavior Representation
HCI	Human-Computer Interface
HLA	High Level Architecture
IDA	Institute for Defense Analyses
I/O	Input/Output
IPT	Integrated Product Team
IT	Information Technology
IW	Information Warfare
JMASS	Joint Modeling and Simulation System
JROC	Joint Requirements Oversight Council
JSIMS	Joint Simulation System
JTA	Joint Technical Architecture
JWARS	Joint Warfare System
M&S	Modeling and Simulation
MIME	Multipurpose Internet Mail Extensions
MOE	Measure of Effectiveness
MOP	Measure of Performance
MORS	Military Operations Research Society
MRM	Multiresolution Modeling
MSRR	Modeling and Simulation Resource Repository
NBC	National Broadcasting Corporation

NGO	Non-governmental Organization
NIMA	National Image and Mapping Agency
NRC	National Research Council
O&S	Operations and Support
OO	Object-oriented
OOTW	Operations Other Than War
OPLAN	Operations Plan
OPS	Operational Position Standards
OPTEMPO	Operations tempo
OR	Operations Research
OSD	Office of the Secretary of Defense
OT	Operational Test
PA&E	Program Analysis and Evaluation
PDU	Protocol Data Unit
PERSTEMPO	Personnel tempo
PM	Program Manager
POM	Program Objective Memoranda
QDR	Quadrennial Defense Review
R&D	Research and Development
RTI	Run Time Infrastructure
S&T	Science and Technology
SAIC	Science Application International Corporation
SBA	Simulation Based Acquisition
SEDRIS	Synthetic Environment Data Representation and Interchange Specification
SIMNET	Simulation Network
SIMSCRIPT	A simulation language
SIMTECH	Simulation Technology
SOM	Simulation Object Model
SPI	Strategic Perspectives, Inc.
TAFIM	Technical Architecture for Information Management
TOR	Terms of Reference
TRM	Technical Reference Model
UML	Unified Modeling Language
USA	United States Army
USACOM	US Atlantic Command
USAF	United States Air Force
V&V	Validation and Verification
VPI	Virginia Polytechnic Institute
VRML	Virtual Reality Modeling Language

VTC	Video Teleconferencing
VV&A	Verification, Validation, and Accreditation
VV&C	Verification, Validation, and Certification
WG	Working Group
WMD	Weapons of Mass Destruction